Zoological Atlas

Anatomy of Vertebrates

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ZOOLOGICAL ATLAS

(INCLUDING COMPARATIVE ANATOMY)

WITH PRACTICAL DIRECTIONS AND EXPLANATORY TEXT

For the Use of Students

231 COLOURED FIGURES AND DIAGRAMS

BY

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VERTEBRATA.

W. & A. K. JOHNSTON
EDINBURGH AND LONDON
1881

Dedicated

(BY PERMISSION)

TO

THE HONOURABLE LORD SHAND,

PRESIDENT OF THE WATT INSTITUTION AND SCHOOL OF ARTS,

WHOSE UNTIRING EFFORTS AND DEVOTED ZEAL IN THE CAUSE OF TECHNICAL EDUCATION
HAVE HELPED TO RAISE THE INSTITUTION TO THE HONOURABLE POSITION
IT NOW HOLDS AMONG THE TRADE SCHOOLS OF THE COUNTRY.

PREFACE.

THE object of this work is to help the student in the examination and dissection of the leading types of animal life. Directions are given how to proceed, and drawings made of the various points to be noted, accompanied by suitable and brief explanations.

The same general plan has been followed as in the "Biological Atlas," and the animal portion of that work may be regarded as an introduction to the present.

Amid the multiplicity of forms, such a selection has been made as will, it is believed, lay a good foundation for more extended study. The range of choice was, however, somewhat limited by the fact that the subjects for dissection must be sizable and easily obtainable, so that it is to be borne in mind, if some of the forms are not the best, they are the most convenient.

For practical purposes the Vertebrata are considered first, not merely because they are as a rule of good size, but chiefly because they are all built on one fundamental pattern. It is well known that students are often discouraged at the outset of their Natural History studies, and their progress retarded, by the mass of new names to which they are introduced. The "language of the science" must of course be learned, but, as in learning other languages, frequent repetition cannot be too much insisted on. Now in commencing with the Vertebrata there is such a community between the different groups—Fish, Amphibian, Reptile, Bird, and Mammal —that the mind is not distracted by a succession of new names as in the lower forms, and the constantly recurring terms gradually and almost without effort become familiar.

The Skate and Cod have been chosen to represent the cartilaginous and bony Fishes respectively. The Salamander represents the tailed Amphibian, and although not a British form like the Newt, it may be readily procured from naturalists. Reptiles are not usually considered to come within the scope of Elementary Practical Work, but the Tortoise, if not a central form, is yet an instructive specimen, and may be taken to fill that gap. Of the Pigeon and Rabbit as representing Bird and Mammal nothing need be said. It will be found that when the course laid down has been faithfully followed, the student will have little difficulty in examining other members of the different groups. He will derive great assistance from Rolleston's "Forms of Animal Life," should time and opportunity permit of the practical examination of numerous specimens.

In determining the bones in the various skulls, I have been guided mainly by the standard work on that subject, viz. Parker & Bettany's "Morphology of the Skull." With regard to the Practical Directions, it was no part of my plan to give instructions for the preservation of specimens; but that part of the subject has been fully and ably treated by Professor Flower, F.R.S., Conservator of the Museum of the Royal College of Surgeons of England, in *Nature*, Nos. 372, 374, and 375.

The necessity for some such work as this is shown by the great importance attached to practical work by such eminent authorities as Professors Huxley and Macalister. Thus Professor Huxley in his preface to the "Anatomy of Invertebrated Animals" writes: "The dissection of a single representative of each of the principal divisions of the Invertebrata will give the student a more real acquaintance with their comparative anatomy than any amount of reading of this or any other book." Professor Macalister, of Dublin University, also remarks: "In a practical science such as Zoology it is only by the examination of specimens that any knowledge of the science worth acquiring can be obtained, and the function of a book is to assist in practical study." That is the avowed aim of this book, and the student will be able to judge of the accuracy of the descriptions and drawings when he has examined the objects for himself.

EDINBURGH, *April* 1881.

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PLATE I.—THE SKATE.

EXTERNAL CHARACTERS AND INTERNAL PARTS.

THE common Skate is a very convenient form with which to begin the practical study of the class of Fishes, inasmuch as it is of such a size that the understanding of its structure is not complicated by difficulties of minute dissection, its cartilaginous skeleton is easily cut up, and it retains throughout life a great many of those peculiarities which are found in other vertebrates only in their embryonic condition.

Its body is extremely flattened, but instead of being laterally compressed like many flat fish (such as the Flounder), so that it lies on one *side*, its dorsal surface is naturally uppermost. It is a ground-feeder, appropriating almost everything it can find, and in keeping with this habit its wide mouth, situated on the under surface of the body, is provided with teeth sometimes pointed to tear or flat to crush. The tail is long, slender, and flexible, armed with sharp spines, and from the way in which it wields it—doubling it upon its body so that the force of the blow may be increased—forms a formidable weapon either of offence or defence.

The Dog-fish, belonging to the same order, might be chosen instead, from its possessing the ordinary fish-shape, but the flattened form of the Skate is so adapted to the dissecting-table that it more than counterbalances this drawback.

EXTERNAL CHARACTERS—

FIGS. 1, 2. An entire specimen may be permanently preserved by hanging up in an airy place and drying. A small specimen is most convenient for this purpose, and the "Mummy Skate" requires no further preparation.

Head with tapering snout.

Tail with two dorsal fins and one caudal fin.

Placoid scales (Gr. *plax*, a plate), each consisting of an exposed portion or spine, and an embedded basal portion or bony plate.

Pectoral fins, enormously developed on each side of body.

Pelvic fins, each two-lobed.

(Claspers, in the male only, two elongated organs at base of tail.)

Orbits or sockets in which eyes are lodged.

Spi'racles (L. *spiro*, I breathe) leading into mouth, and having rudimentary gills or pseudo-branchiæ (Gr. *pseudos*, false; *branchia*, a gill) on anterior face.

FIG. 3. Median openings { Mouth with teeth on upper and lower jaw. / Clo'acal opening (L. *cloaca*, a sewer).

Paired openings { Nostrils. / Abdominal pores leading into abdominal cavity.

Other openings { Branchial apertures or gill-clefts, five on each side. / Sensory tubes with gelatinous contents, numerous and symmetrically arranged on both sides of the body.

Fronto-nasal process, a kind of upper lip marked off on each side by a groove extending from nostril to corner of mouth.

Pectoral arch or shoulder-girdle indicated beneath the skin.

Pelvic arch or hip-girdle indicated beneath the skin.

INTERNAL PARTS—

FIG. 4. With a pair of scissors slit up the ventral body-wall, commencing in front of cloacal aperture and ending behind mouth. First expose abdominal cavity by cutting away body-wall between hip and shoulder girdles. Next expose pericardial cavity and gill-cavities by removing ventral wall anterior to shoulder-girdle.

In *Abdominal cavity* note—

Liver, three-lobed, with gall-bladder.

Stomach embracing spleen.

Intestine with spiral markings, opening into cloaca.

Rectal gland, a small red body.

In *Pericardial cavity*, separated from the former cavity by a fibrous partition, note—

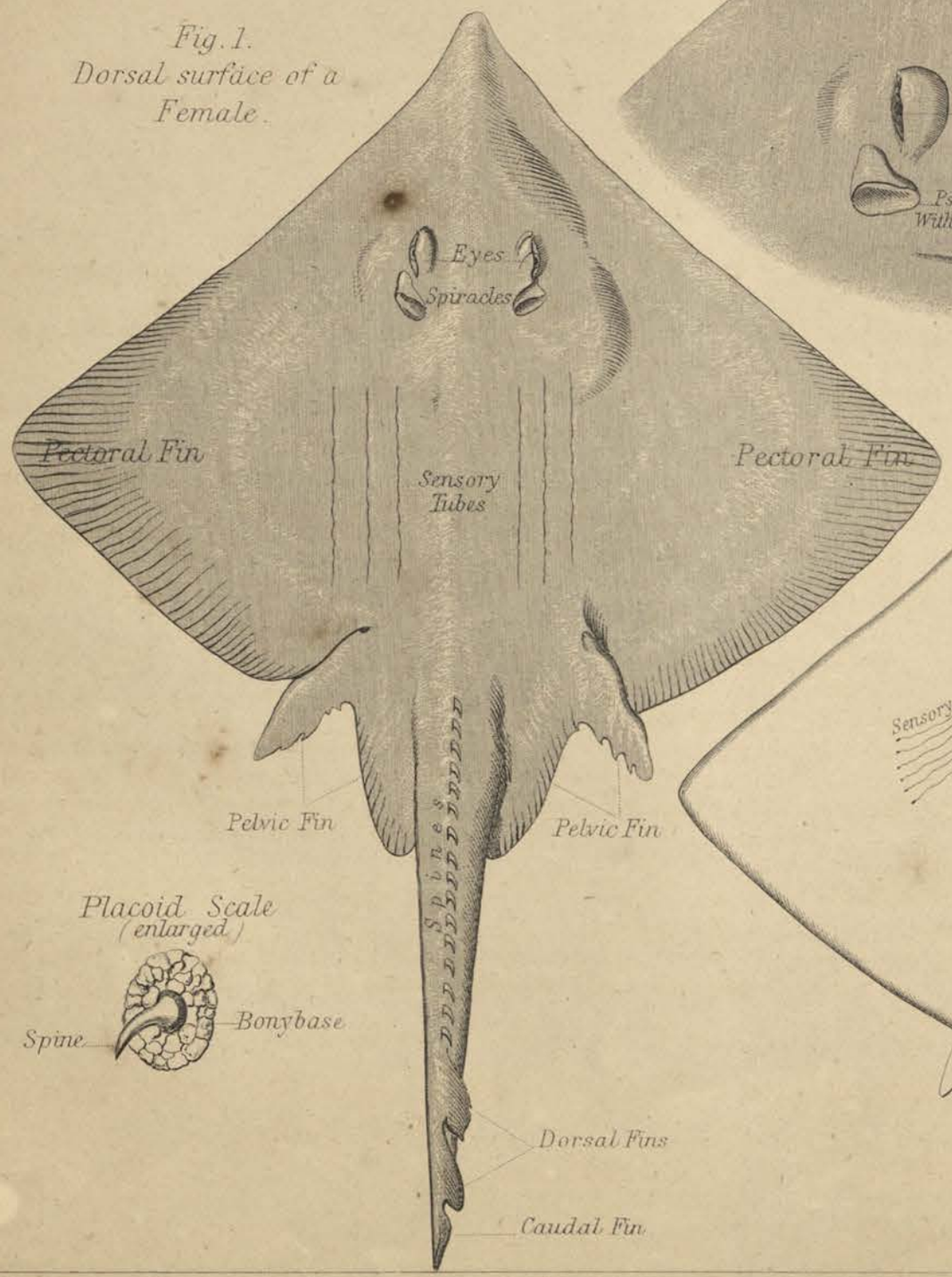
Heart { Ventricle leading into pylangium (Gr. *pule*, gate; *angeion*, a vessel), or conus arteriosus, thence into synangium (Gr. *sun*, together), or bulbus arteriosus. / Auricle communicating with sinus venosus (L. venous sinus).

Gill-cavities, five on each side.

Gills, four and a half on each side, each consisting of branchial arch separating gill-cavities and supporting branchial filaments.

Vessels supplying gills—the posterior innominate arteries on each side, and the ventral aorta in middle, dividing into anterior innominate arteries.

Fig. 1.
Dorsal surface of a Female.



Placoid Scale (enlarged)

Fig. 2. Head end of same enlarged

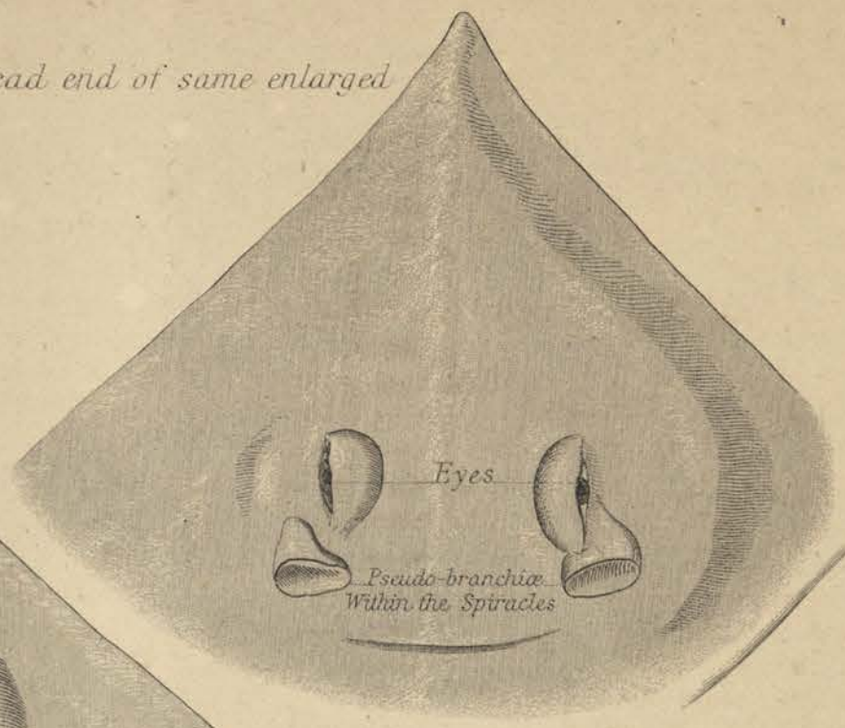


Fig. 3. Ventral surface of same

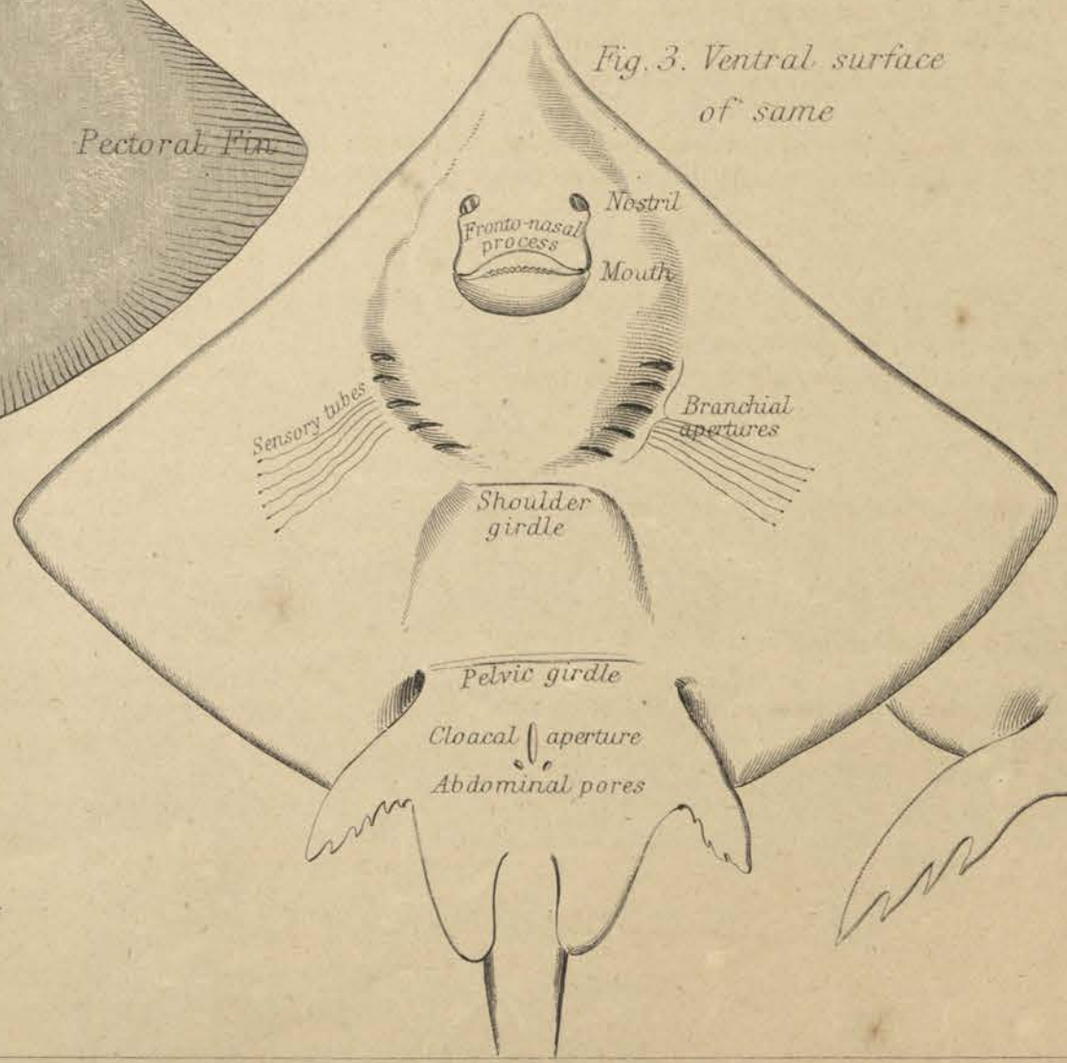
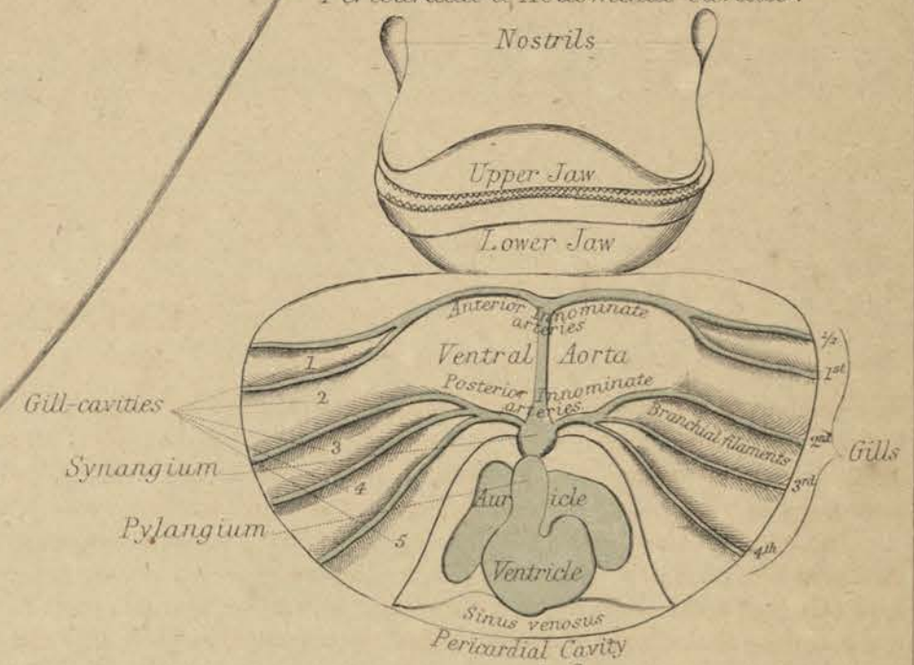


Fig. 4. Dissection from ventral surface, showing Pericardial & Abdominal cavities.



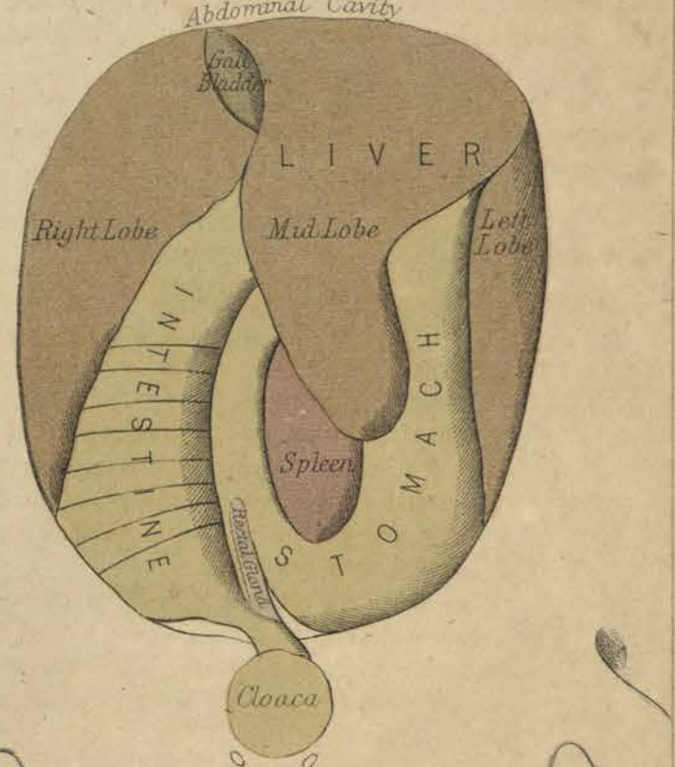


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PLATE II.—THE SKATE—*continued.*

INTERNAL ORGANS AND ENDOSKELETON.

FIG. 1. Make a dissection from left side by cutting away as much as necessary of pectoral and pelvic fins, then remove side walls of neural, oral, pericardial, and abdominal cavities, and lay out alimentary canal, etc., so as to show the *form* of the various parts. (To study *position* and *relation* of parts, freeze specimen as directed in case of Rabbit.)

- Skeleton . . . . . { Spinal column enclosing spinal cord, and skull enclosing brain. / Pectoral arch cut through (uncoloured).
- Nervous system . . . Brain and spinal cord.
- Alimentary system . . { Mouth enlarging into pharynx, with spiracle and branchial apertures in side walls. / Œsophagus or gullet expanding into— / Stomach, with its thickened and narrow posterior end, the pylorus. / Intestine { Duodenum. / Colon. / Rectum. } / Liver, three-lobed. / Pancreas, white, with its duct opening into duodenum.
- Spleen, red.
- Circulatory system . . . { Heart. / Ventral aorta. / Dorsal aorta.
- Respiratory system . . Gill-clefts shown.
- Urino-genital system . . { Kidney. / Ovary. / Oviduct.

DIAGRAM 1. Neural cavity containing spinal cord.
Abdominal cavity containing—
Alimentary canal suspended by lining membrane or peritoneum (Gr. *peri*, around; *teino*, I stretch).
Dorsal aorta.
Kidneys supported on ventral face by peritoneum.
Ovaries suspended by peritoneum, here called mesovarium.

Preparation of Skeleton.—Carefully remove surrounding material from cartilage, then place in ten per cent. solution of nitric acid for a few days, afterwards steeping in water to remove acid. Examine while wet, as cartilage shrivels up in drying.

FIGS. 2, 3.

- Anterior vertebral plate, representing a number of vertebræ . . . . { Ventral portion, representing centra. / Lateral ridges, representing transverse processes. / Dorsal crest, representing neural spines. / Odontoid process fitting between the two occipital condyles of the skull. / Articular surfaces for the two condyles. / Foramina, a double row on each side for the passage of dorsal and ventral roots of spinal nerves.

FIG. 4.

- Trunk vertebra . . . . { Body or centrum, circular, biconcave, with short lateral projections or transverse processes. / Neural arch { Neural processes, triangular, one on each side. / Neural plates, hexagonal, one on each side, alternating with centra. / Neural spine surmounting neural arch and alternating with neural plates.

Ribs, rudimentary, attached to ends of transverse processes (not shown).

FIG. 5.

- Caudal vertebra . . . { Centrum. / Hæmal arch (Gr. *haima*, blood), formed by two inferior processes united at their ventral ends, and enclosing caudal artery and vein. / Neural processes. / Neural spine.

FIG. 6.

- Pectoral arch . . . . { Dorsal portion { Scapula (L. shoulder-blade). / Supra-scapula, attached to anterior vertebral plate above and scapula below. } / Ventral portion—coracoid. / Glenoid facets (Gr. *glēnē*, a shallow depression), three depressions on each side, into which the three basal cartilages of fin fit. / Fontanelles, three large perforations on each side.

FIG. 7.

- Pectoral fin . . . . . { Pro-pterygium (Gr. *pro*, before; *pterux*, a wing) / Meso-pterygium (Gr. *mesos*, middle) / Meta-pterygium (Gr. *meta*, behind) } three basal cartilages. / Fin-rays, long, numerous, and jointed.

FIG. 8.

- Pelvic arch . . . . . { Only a ventral portion consisting of a single cartilage giving off a— / Pre-pubic process and an iliac process on each side. / Acetabular facets, two on each side, giving attachment to—
- Pelvic fin . . . . . { Pre-axial fin-ray supporting anterior lobe, and a cartilage supporting posterior lobe, and giving attachment to numerous fin-rays.

Fig. 1. Longitudinal vertical section as far as cloaca, with viscera laid out

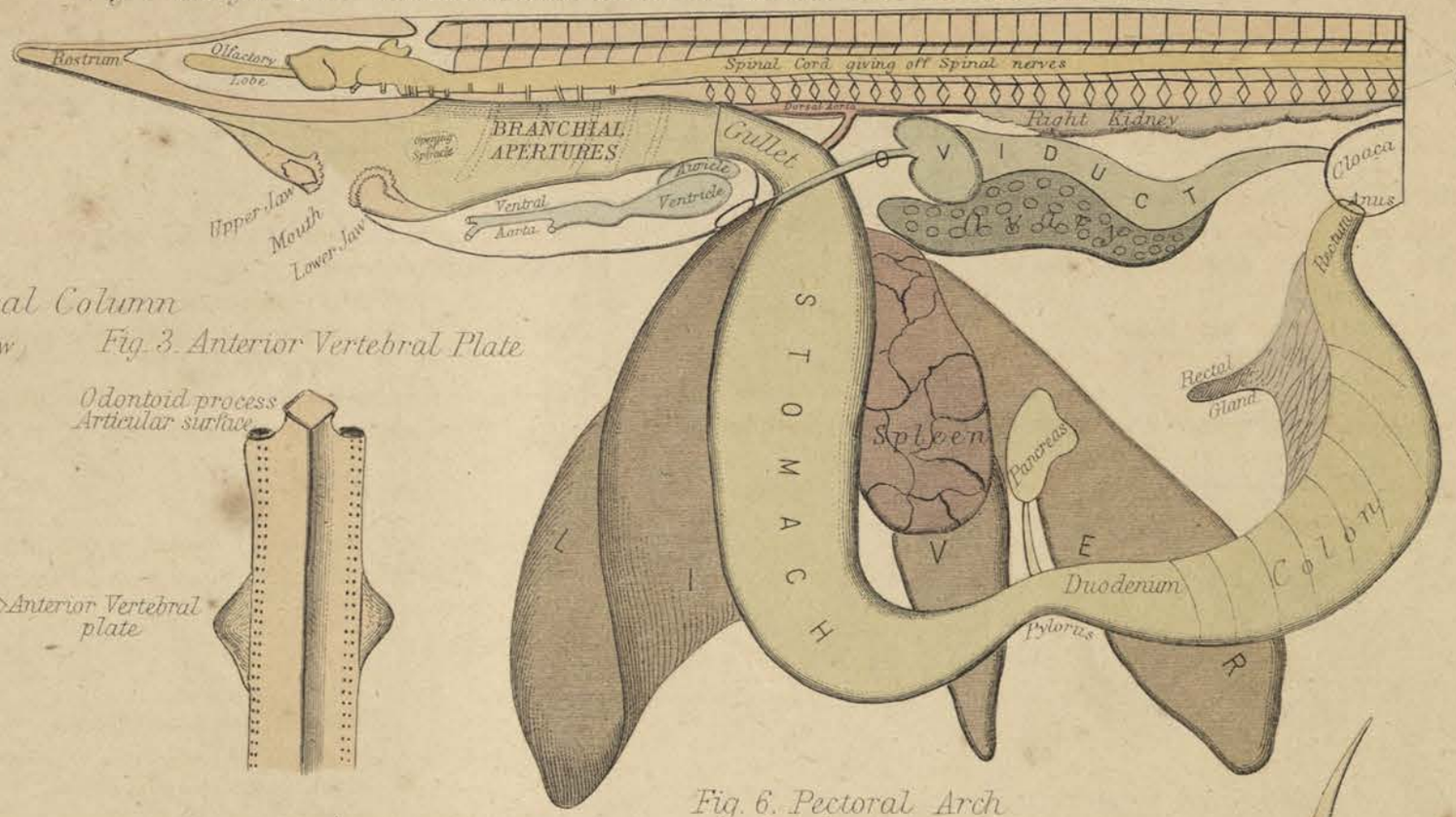

Diagram 1 Transverse section of Abdomen

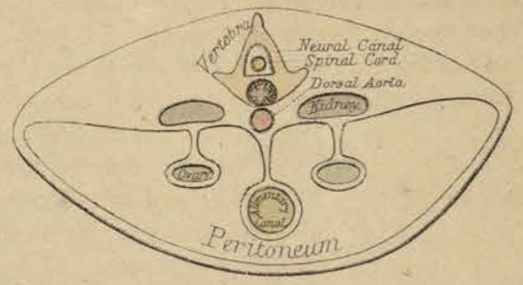

Fig. 2. Vertebral Column
(ventral view)

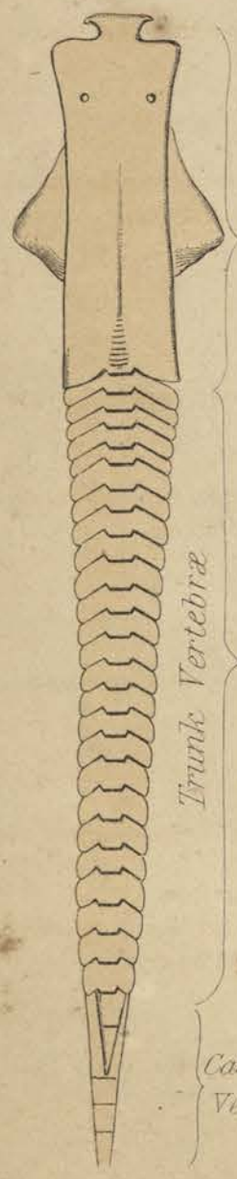

Fig. 3. Anterior Vertebral Plate

Fig. 4. Trunk Vertebræ
a. end view b. longitudinal section

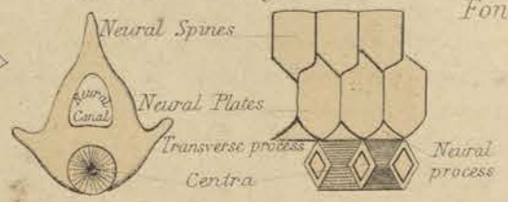

Fig. 5. Caudal Vertebræ
a. end view b. side view

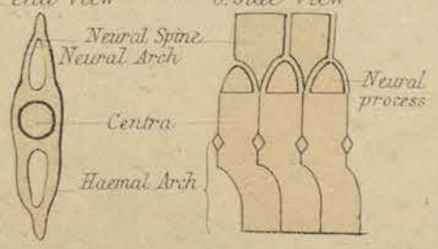

Fig. 6. Pectoral Arch
(anterior view)

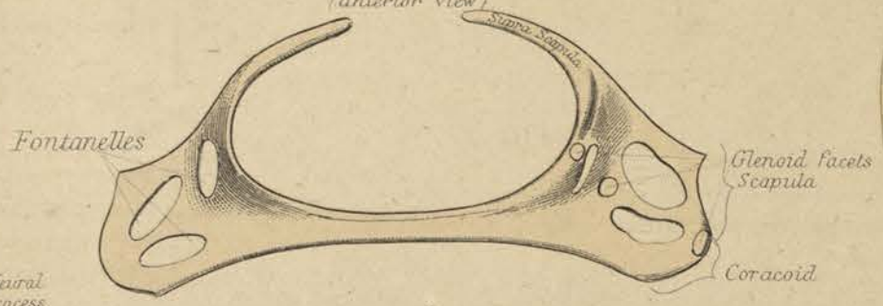

Fig. 8. Pelvic Arch & Fin
(anterior view)

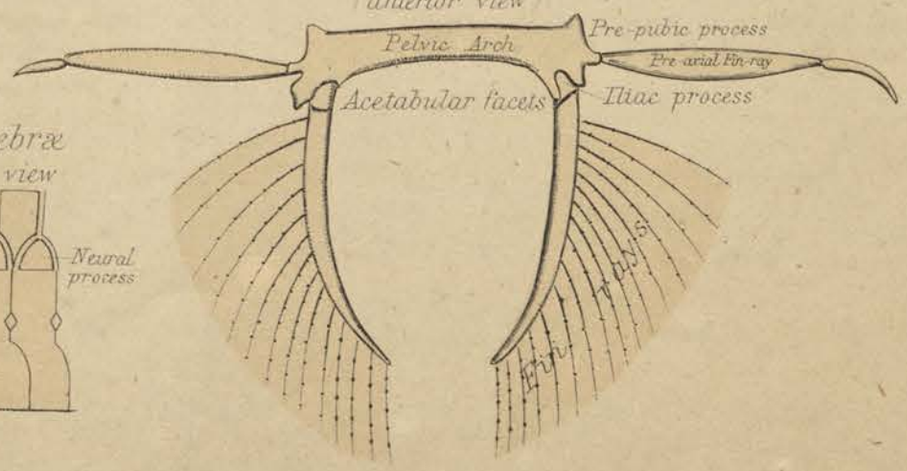

Fig. 7. Pectoral Fin

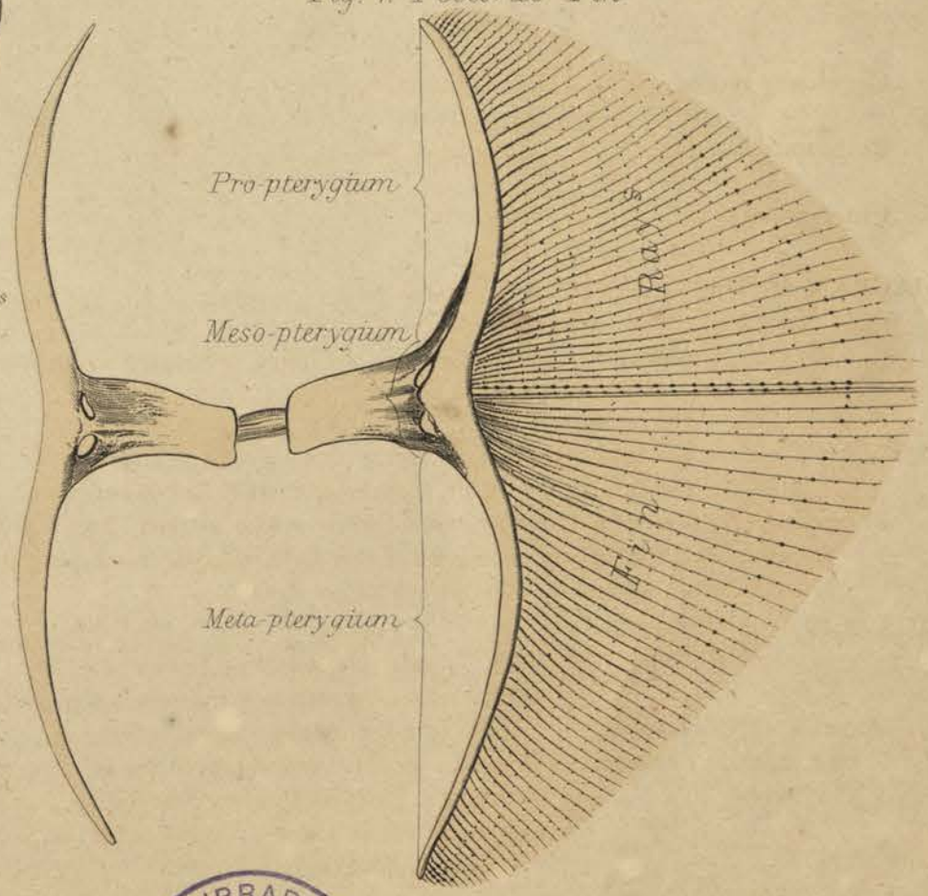

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PLATE III.—THE SKATE—*continued.*

ENDOSKELETON—*continued.*

FIGS. 1 and 2. The regions of the skull and the various arches may be grouped as follows:—

1. Cranium (Gr. *kranion*, the skull) or brain-case proper . . .
   - Occipital or posterior region, broad and low, with occipital condyle on each side of foramen magnum.
   - Interorbital region, narrow, with posterior fontanelle on top. (The name fontanelle (L. *fons*, a fountain) was originally applied to the membranous spaces between the bones of the skull in a young child's head, because the *pulsating* of the arteries could be felt there, now it is used for other spaces enclosed by membrane.)
   - Internasal region, with anterior fontanelle, extending along the top of rostrum.
   - Rostrum (L. the snout), the pointed anterior region.
   - Labial cartilages, one pair fringing anterior end of rostrum, the other three pair about nasal aperture.
2. Sense-capsules . . .
   - Auditory capsules bulging on each side of posterior region.
   - Nasal capsules, on each side of internasal region, with antorbital cartilages attached.
3. Jaw-apparatus . . .
   - Upper jaw, or palato-quadrate arch, consisting of two cartilages united in middle line and attached by ligament to spiracular cartilage and hyomandibular, and articulating with lower jaw.
   - Lower jaw, or mandible, consisting of two Meckel's cartilages united in middle line.
   - Pre-spiracular cartilage, or meta-pterygoid, attached by ligament to auditory capsule above, and below, its attachment becomes continuous with that of hyomandibular.
4. Hyoid arch . . . .
   - Hyomandibular, articulating with auditory capsule, and attached by ligament to jaw apparatus.
   - Hyoid, attached to preceding by interhyal ligament, and composed of—
     - Epi-hyal (Gr. *epi*, upon).
     - Cerato-hyal (Gr. *keras*, a horn).
     - Hypo-hyal (Gr. *hupo*, under).
5. Branchial arches . .
   - Five pair, repeating structure of hyoid arch, each consisting originally of four segments—
     1. Pharyngo-branchial.
     2. Epi-branchial.
     3. Cerato-branchial.
     4. Hypo-branchial.
   - First hypo-branchials united into one piece (fig. 2).
   - Fifth hypo-branchials united to form basi-branchial plate (fig. 2).
   - Upper forked portion common to the fourth and fifth arch, consisting of first segment of fourth, and first and second of fifth united (fig. 1, *a*).

FIGS. 3, *a*, *b*, and 4—Chief points of difference in skull of Dog-fish as compared with that of Skate—

- Pre-nasal cartilage in place of largely developed rostrum.
- One fontanelle.
- First labial cartilages extending over nasal capsules.
- Five pair of labial cartilages.
- Antorbital cartilage only represented by a small process.
- Supra-orbital ridge with sphenotic process.
- Spiracular cartilage, small, and included in the meta-pterygoid ligament.
- Hyomandibular, closely connected with rest of hyoid.
- Hyoid arch distinct from first branchial arch.
- Basi-hyal present.

FIG. 5, *a*, *b*, *c*.—Two brains will be required. For the ventral and side view use a brain that has been removed from the skull and hardened in spirit. For the dorsal view remove the roof of the skull and examine the brain as it lies in the clear arachnoid fluid.

- Olfactory lobes expanding at their ends, and giving off olfactory nerves.
- Cerebral hemispheres, solid throughout.
- Optic thalami with third ventricle between. Pineal gland connected with roof and pituitary body with prolongation of floor of third ventricle.
- Optic lobes meeting in middle line.
- Inferior lobes partly beneath optic lobes and optic thalami.
- Saccus vasculosus, a ruddy tri-lobed sac.
- Cerebellum, with sulci (L. furrows) on its surface.
- Medulla oblongata, with restiform bodies on either side.

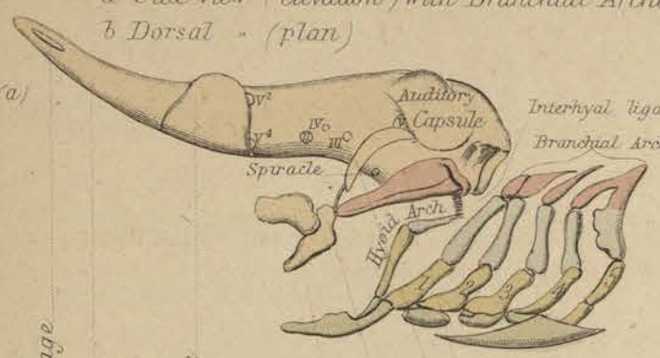
FIG. 6. Cranial nerves (see also description of fig. 1, Plate IV.).

Name.	Origin.	Distribution.
I. Olfactory.	Olfactory lobes.	Nasal organs.
II. Optic.	Optic thalami.	Eyes.
III. Oculo-motor.	Crura cerebri.	Muscles of eye: Superior rectus. Internal rectus. Inferior rectus. Inferior oblique.
IV. Pathetic.	Beneath cerebellum.	Superior oblique muscle.
V. Trigeminal.	Medulla oblongata.	Various.
VI. Abducent.	Medulla oblongata—middle line below.	External rectus muscle.
VII. Facial.	Medulla oblongata.	Various.
VIII. Auditory.	Medulla oblongata.	Ear.
IX. Glossopharyngeal.	Medulla oblongata.	Posterior face of hyoid arch, and anterior face of first branchial arch.
X. Pneumo-gastric or vagus.	Medulla oblongata.	Various.

Brachial plexus formed by the union of a number of spinal nerves and distributed to pectoral fin.

Fig. 1. Elevation & Plan of Skull.

a Side view (elevation) with Branchial Arches
b Dorsal " (plan)



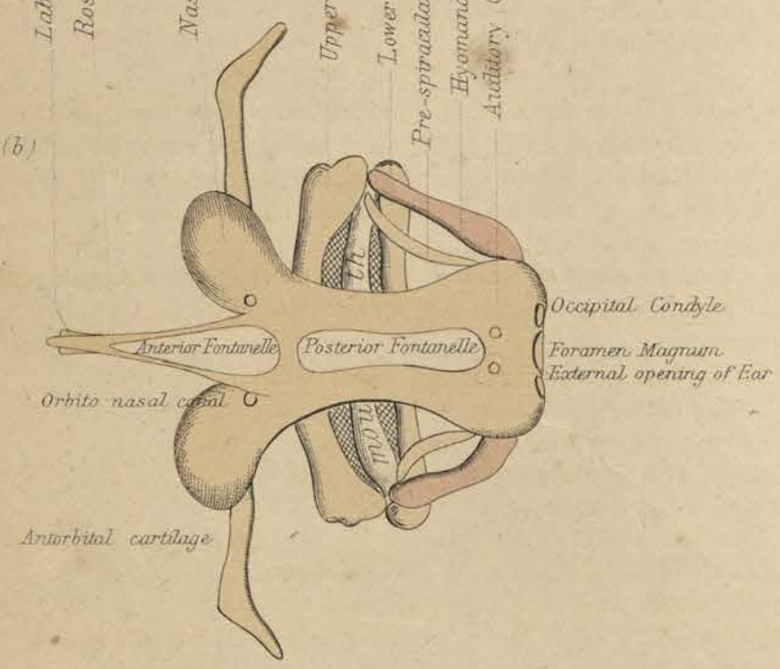


Fig. 2. Branchial Arches
(ventral view)

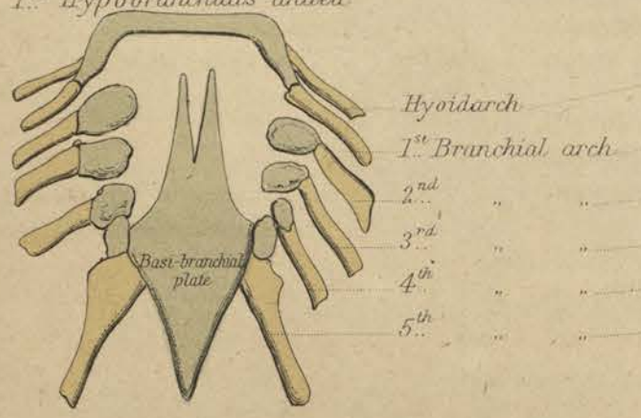
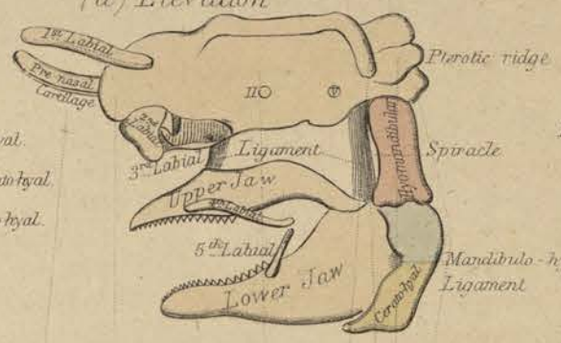


Fig. 3. Elevation & Plan of Skull of Lesser Spotted Dogfish

(a) Elevation



(b) Plan

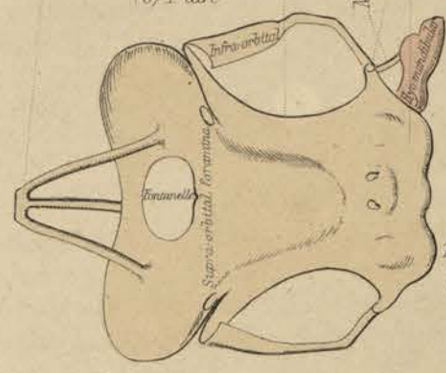


Fig. 4. Branchial Arches of same
(ventral view)

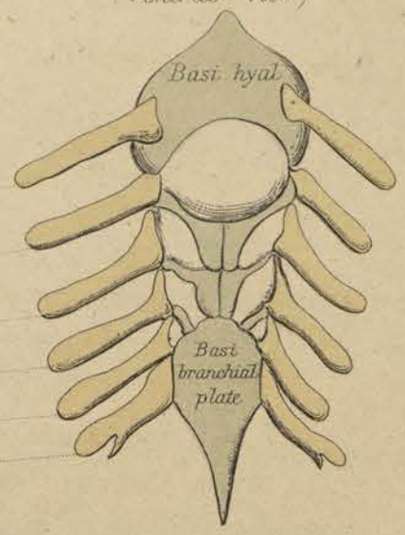


Fig. 5. Brain

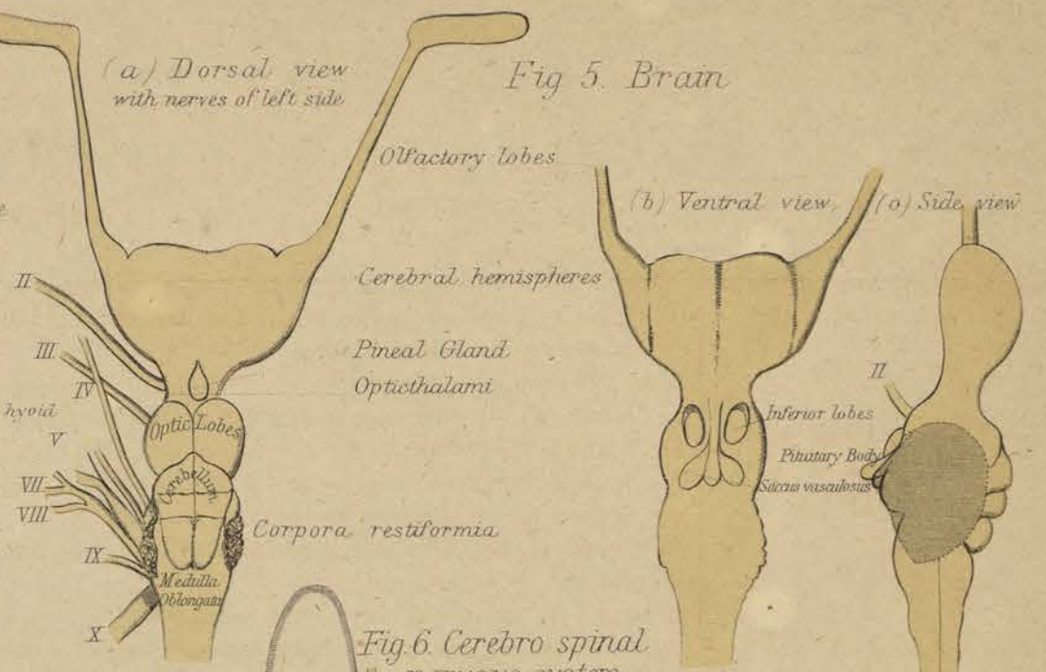


Fig. 6. Cerebro spinal nervous system
(dorsal view)

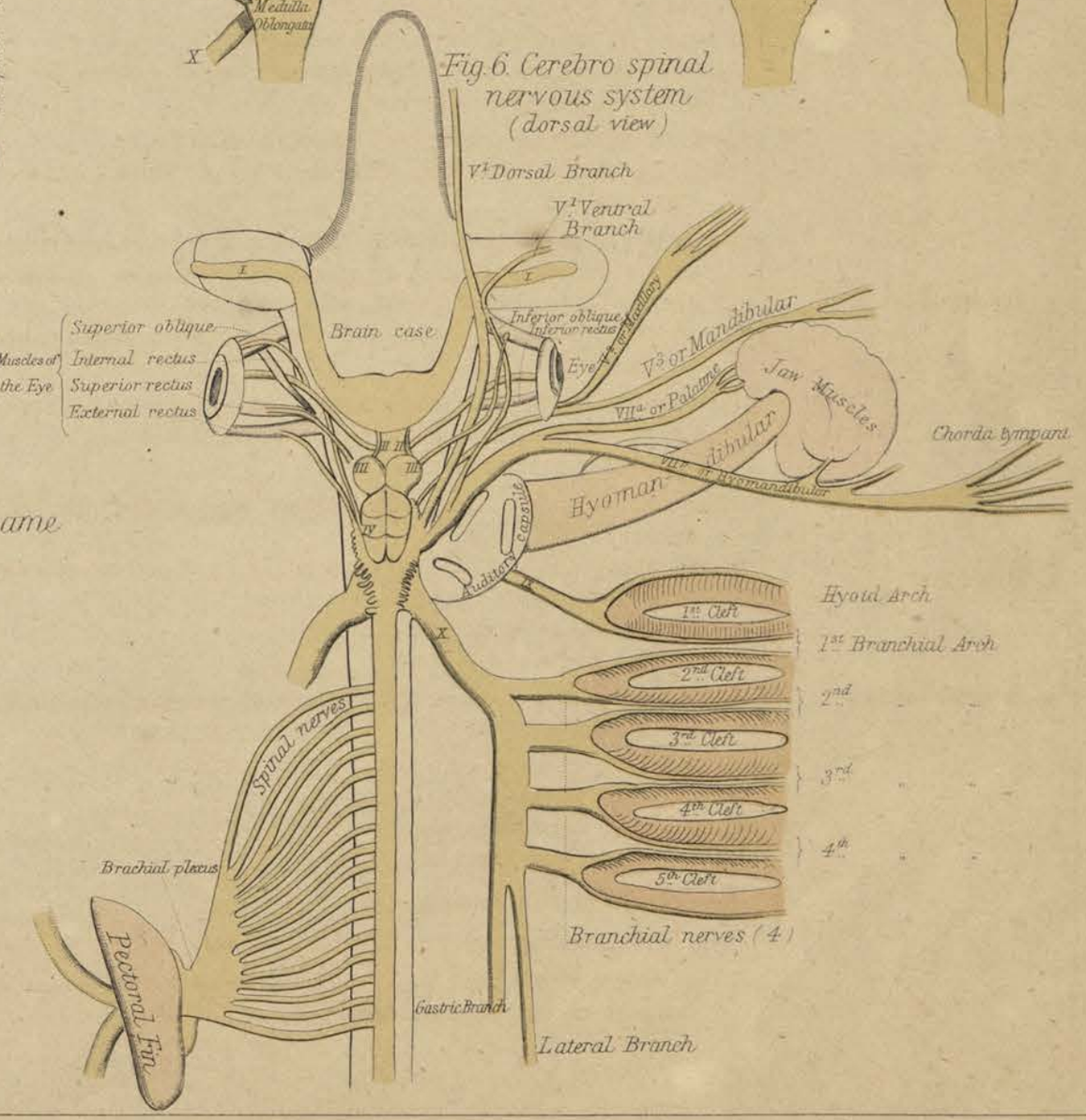


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PLATE IV.—THE SKATE—*continued.*

NERVOUS SYSTEM AND SENSE-ORGANS (*concluded*); ALIMENTARY AND CIRCULATORY SYSTEMS.

FIG. 1. Course and distribution of V., VII., IX., and X., cranial nerves—
- V^1. Orbito-nasal passes above eye, through nasal capsule, and along side of rostrum.
- V^2. Maxillary passes outside of nasal chamber, then separating into filaments, goes towards margin.
- V^3. Mandibular to outer side of lower jaw.
- V^4. Palato-nasal passes beneath eye, along bottom of nasal chamber, to base of rostrum.
- VII^a. Palatine sending branches to roof of mouth and pseudo-branchia.
- VII^b. Hyomandibular to sensory tubes at angle of jaw, and giving off chorda tympani to inner side of lower jaw.
- IX. Glossopharyngeal.
- X. Pneumo-gastric giving off four branchial nerves, with gastric branch to stomach and lateral branch to heart, etc.

FIG. 2. Olfactory lobe expanding into elongated band on dorsal surface of nasal sac.
Mucous membrane raised into a ridge on ventral surface, opposite to expansion of olfactory lobe.
Transverse folds of mucous membrane passing off on each side of central fold.

FIG. 3. Eye removed and dissected under water—
Pedicel with universal joint attaching eye to skull.
Sclerotic coat composed of cartilage, and passing into cornea, composed of transparent connective tissue.
Choroid coat pigmented and vascular, passing into ciliary processes, and connected by ciliary muscle with iris.
Retina inside choroid.
Lens contained in capsule attached to ciliary processes.
Vitreous humour between lens and retina.
Aqueous humour between lens and cornea.
Optic nerve radiating over inner surface of retina.

FIG. 4. External opening leading into aqueductus vestibuli.
Vestibule filled with fluid, and containing small calcareous particles.
Semicircular canals, each with ampulla. Anterior and posterior canals are altogether separate, and not partly united, as in higher vertebrata.

FIG. 5. The males generally have pointed teeth, while the females have flat ones.

FIG. 6. After examining the parts of the alimentary canal in their natural relations, and making out bile and pancreatic ducts, remove liver, pancreas, and spleen. Then detach as much as necessary of intestine in order to examine pyloric and spiral valves, washing out, inflating with air, and drying.
Instead of distending with air, a weak solution of chromic acid (5 per cent.) may be used. Place intestine thus distended in the same solution for a few days, when the spiral valve becomes thoroughly hardened and easily cut. The wet method is to be preferred to the dry one.
Œsophagus or gullet leading from pharynx and dilating into—
Stomach, ending posteriorly in a narrow passage—the pyloric valve.
Intestine { Duodenum succeeding pylorus. / Colon with spiral valve in its interior. / Rectum with rectal gland attached.
Liver with bile-duct leading from gall-bladder and opening into duodenum.
Pancreas with duct opening opposite to bile-duct.
Spleen ductless and highly vascular.
Mesentery, or fold of peritoneum suspending stomach, is called mesogaster.
Mesentery attaching spleen to stomach is called gastro-splenic omentum.

FIGS. 7 and 8. Heart removed by detaching it as shown in fig. 7; then open up ventricle and conus arteriosus as in fig. 8.
Sinus venosus leading from Cuvierian sinus on both sides into—
Auricle, thin walled, and communicating with ventricle by auriculo-ventricular aperture.
Ventricle with thick spongy walls.
Pylangium, or conus arteriosus, with three rows of valves—five in each row.
Synangium, or bulbus arteriosus, from which the blood-vessels arise.

FIG. 9.

Arteries—
- Ventral aorta dividing into two anterior innominate trunks, each of which divides into two afferent branchial vessels supplying gills.
- Posterior innominate trunks, each dividing into three afferent branchial vessels.
- Efferent branchial vessels, one from each half-gill, uniting to form dorsal aorta.
- Carotid artery arising from efferent branchial vessel of hyoid arch, and giving off branch to pseudo-branchia and internal carotid to brain.
- Vertebral artery arising from anterior efferent branchial trunk, and going to brain and spinal cord.
- Dorsal aorta giving off { Brachial to pectoral fin. / Cœliac { Gastro-hepatic to stomach and liver. / Duodenal to duodenum. } / Mesenteric to intestine, pancreas, and spleen. / Genital to testis. / Renal to kidney. / Caudal, the continuation of the dorsal aorta in the tail. }

Veins—
- Cuvierian sinus corresponds nearly to superior vena cava, and receives the two following vessels:—
- Anterior cardinal vein from head, receiving brachial vein from pectoral fin.
- Posterior cardinal vein from posterior parts of body.
- Hepatic sinus.
- Hepatic veins from liver to hepatic sinus.
- Portal vein formed by . . . { Mesenteric from intestine and pancreas. / Lieno-gastric from stomach and spleen. }

FIG. 10. Coloured corpuscles of the blood, oval and nucleated.
Colourless corpuscles, amœboid and nucleated.

Fig. 1. Skull & Branchial Arches with principal nerves

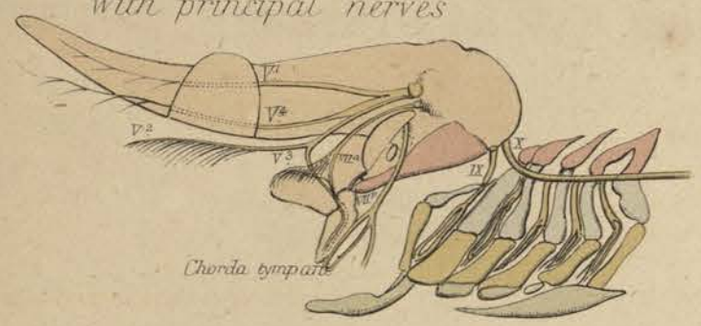

Fig. 2. Nasal capsule removed

Fig. 3. Long^l Vertical section of Eye

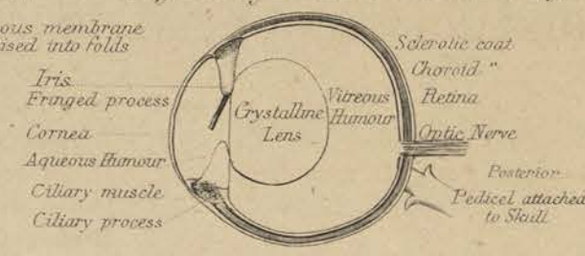

Fig. 4. Ear

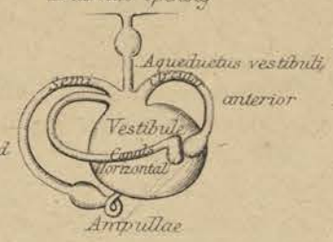

Fig. 6. Alimentary Canal & Appendages

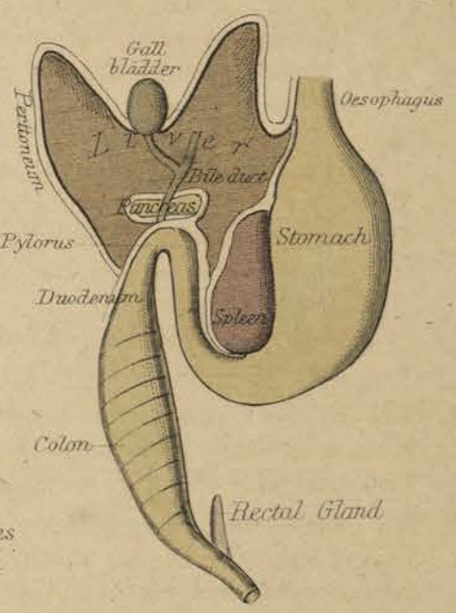

Fig. 7. Dorsal view of Heart

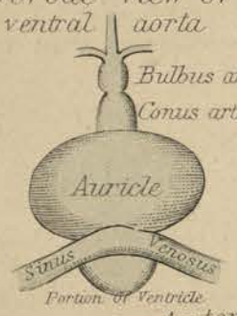

Fig. 8. Ventricle & conus arteriosus laid open ventrally

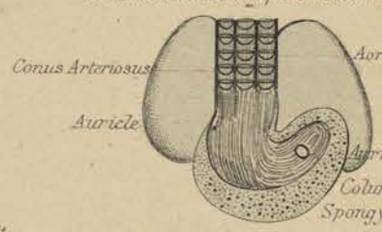

Fig. 10. Corpuscles of the Blood

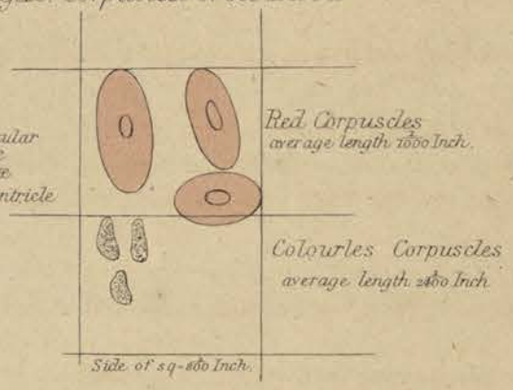

Fig. 9. General Course of Circulation
(semi-diagrammatic)

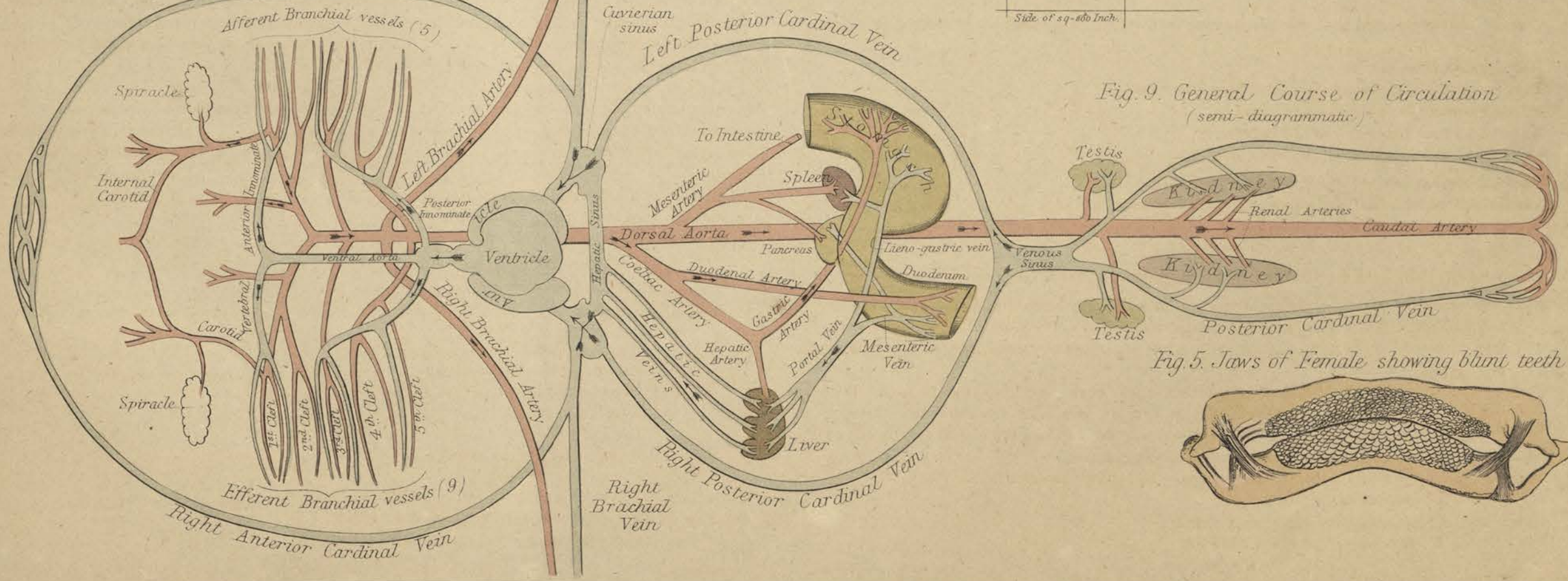

Fig. 5. Jaws of Female showing blunt teeth

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PLATE V.—THE SKATE—*concluded.*

URINO-GENITAL ORGANS.

FIG. 1. The ovaries lie on each side of the vertebral column, supported by a fold of peritoneum—the mesovarium.

After removal of the ovaries the oviducts will be fully seen.

The kidneys are still left after removal of the genital organs, and are covered by peritoneum only on their ventral surfaces.

Ovary, with protuberances upon surface—the Graafian follicles.

Oviduct separate from ovary
- Fallopian tube, the anterior slender portion which unites with tube of opposite side beneath gullet, to open into abdominal cavity.
- Uterus (L. the womb), the posterior dilated portion, with oviducal gland for secreting the egg-purse, and opening into cloaca.

Kidneys with ureters opening into bilobed urinary bladder.

Openings into cloaca . . .
- Rectum.
- Oviduct.
- Urinary bladder opening on urinary papilla.

FIG. 2. The testes have a similar position to the ovaries, and their supporting fold of peritoneum is called mesorchium (Gr. *orchis*, a testicle).

Testes made up of little vesicles and connected with upper end of—

Epididymes (Gr. *epi*, upon; *didumos*, a testicle).

Vasa deferentia, a continuation of contorted tube of epididymis, with posterior end dilated and opening into—

Sperm-sacs.

Urino-genital sinus, with ureters and sperm-sacs opening into it.

Openings into cloaca . . .
- Rectum.
- Urino-genital sinus opening on urino-genital papilla.

FIG. 3. Spermatozoa, found in vas deferens, with thickish spiral head and long vibratile tail.

FIG. 4. Egg-case, commonly known as a "Mermaid's Purse," may be found empty on sea-shore, or may sometimes be squeezed out of female with its contained egg. The specimen figured, picked up on sea-shore, contains the embryo Skate with yelk-bag attached.

It is of leathery texture, with projections at four corners to serve for attachment, and open at one end for respiratory purposes.

CLASSIFICATION—

Sub-Kingdom—Vertebrata—
- Vertebral column.
- Limbs (pectoral and pelvic fins) with internal skeleton.
- Nervous system in dorsal region of body.
- Portal vein from alimentary canal to liver, with a capillary network at both ends.
- Spleen.

Class—Pisces (L. fishes)—
- Fins with fin-rays.
- Limbs in form of fins.

Natural Order—Elasmobranchii (Gr. *elasma*, a plate; *branchia*, a gill)—
- Skeleton cartilaginous.
- Optic nerves form a chiasma.
- Cloaca.
- Heart with several rows of valves in aortic bulb.
- Gills, pouch-like.

Family—Raiadæ (including such genera as Torpedo or Electric Ray, Trygon or Sting-Ray, Myliobatis or Eagle Ray, and Pristis or Saw-fish)—
- Body flattened.
- Gill-clefts on ventral surface.
- Pectoral fins connected with head by antorbital cartilage.

Genus—Raia.

Species—R. batis (L. *batis*, a Skate); without spines in front of eyes or along middle line of back, and R. clavata (L. *clavus*, a spike), or Thornback, etc.

Fig. 1. Female Urino-genital organs spread out-ventral view
Left Ovary removed

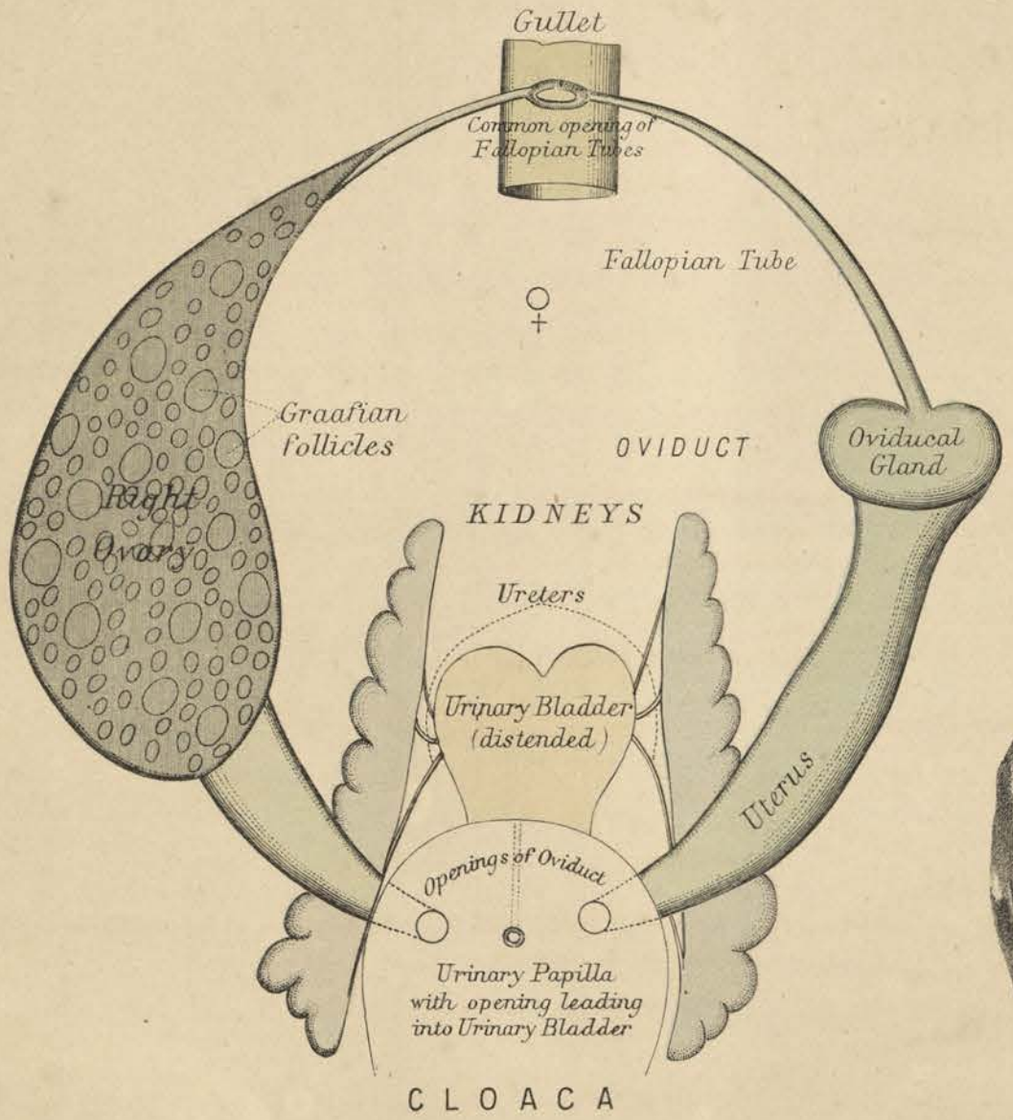

Fig. 3. Spermatozoa

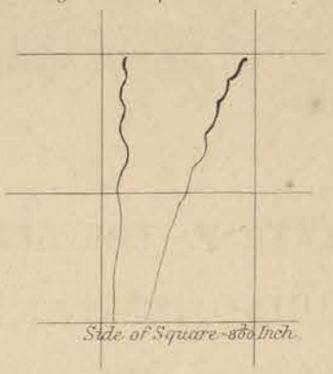

Fig. 4. Egg Case
containing Embryo Skate natural size

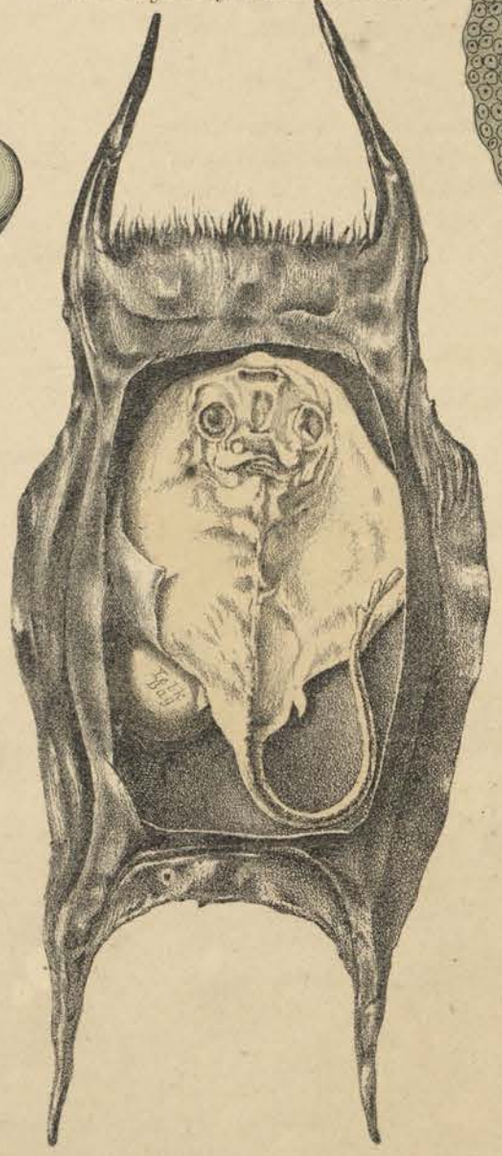

Fig. 2. Male Urino-genital organs-ventral view

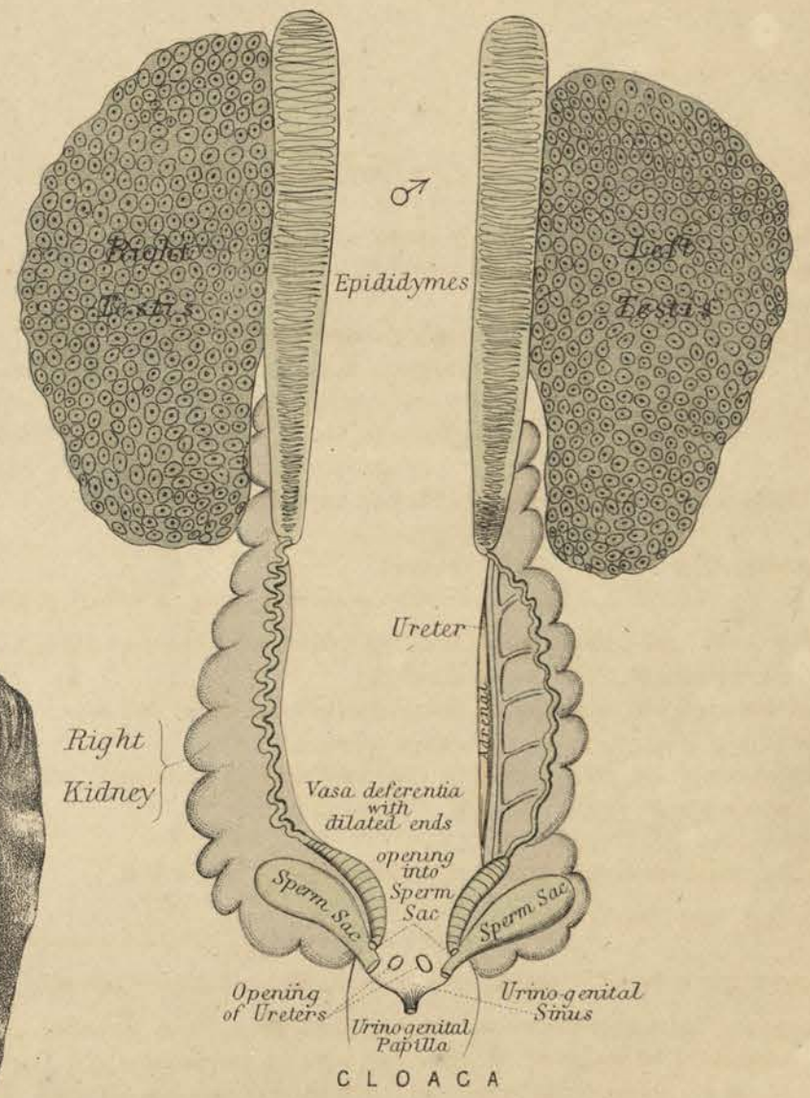

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PLATE VI.—THE COD.

EXTERNAL CHARACTERS AND INTERNAL ORGANS.

The Cod is a representative of the largest group of Fishes in which the skeleton is bony and not cartilaginous. It offers many points of contrast to the Skate, and may be profitably compared with that form both as to points of agreement in structure and points of difference.

Obvious differences exist in the character of the fins, scales, and tail, and in the presence of distinct cranial bones, a gill-cover, and an air-bladder. Also in the absence of a spiral valve in intestine, a cloaca, and a spiracle; and the gill filaments, instead of being united by membrane so as to form a pouch, are comb-like.

The skull of the Cod may be easily disarticulated, and the understanding of its various parts forms a good foundation for the study of the bony skull generally.

The various uses of the Cod are well summed up as follows: "Almost all parts of the Cod are adapted for the nourishment of man and animals, or for some other purposes of domestic economy. The tongue, for instance, whether fresh or salted, is a great delicacy; the gills are carefully preserved to be employed as baits in fishing; the liver, which is large and good for eating, also furnishes an enormous quantity of oil, which is an excellent substitute for that of the Whale, and applicable to all the same purposes; the swimming-bladder furnishes an isinglass not far inferior to that yielded by the Sturgeon; the head, in the places where the Cod is taken, supplies the fishermen and their families with food; the lens are made into necklaces for children; and the ear-bones [otoliths] are often found in the possession of the curious; even their intestines and their eggs contribute to the luxury of the table.

EXTERNAL CHARACTERS—

FIG 1. Mouth with teeth set on little bony elevations, and not at the bottom of a fold of mucous membrane.
Double nostril.
Eye on each side of head.
Barbule on lower jaw.
Operculum (L. a lid) or gill-cover.
Opercular membrane supported by bony rays.
Lateral line extending from top of operculum to base of caudal fin.

Paired fins or limbs	Pectoral just behind head. Pelvic, or ventral, smaller and more anterior.
Median fins	Dorsal, three. Anal, two. Caudal, bilobed.

INTERNAL ORGANS—

FIG. 2. This is a combination of the frozen section (Plate VII.), with a dissection from left side—

Skeleton	Spinal column composed of biconcave vertebræ. Skull composed of flat bones closely united into a box.
Nervous system	Spinal cord dilating into brain. (The brain is much enlarged, as it occupies but a small portion of the cranial cavity.)
Alimentary system	Mouth, with large gape and small tongue in floor. Teeth on both jaws, on vomer, and on pharyngo-branchials, which are united into one mass on either side. Each convex bone thus formed is known as epipharyngeal from its position, and the fifth arch also bears teeth opposite to epipharyngeal. Gullet short and dilating into— Stomach capacious, narrowing at one side into pylorus. Intestine ending in anus. Liver large and bilobed. Pancreas represented by pyloric cæca opening into intestine. Spleen placed in neighbourhood of stomach.
Circulatory system	Heart consisting of single ventricle and auricle. Ventral aorta.
Respiratory system	Branchial arches, five, four gill-bearing. Air- or swim-bladder beneath vertebral column.
Urino-genital system	Kidneys long and narrow, the largest portion directly behind head. Urinary bladder receiving a single ureter. Genital duct in direct communication with genital gland.

Fig 1. Right Side

Fins
Dorsal
Lateral Line
Pectoral Fin
Posterior Nostril
Anterior
Mouth with Teeth
Operculum
Opercular Membrane
Barbule
Caudal Fin
Anal Fins
Pelvic Fin

Fig 2. Longitudinal Vertical Section with Alimentary Canal laid out

Olfactory lobe
Cerebellum
Optic lobe
Cerebral Hemisphere
Orbital fossa
Premaxilla
Dentary
Auricle
Ventricle
Ventral Aorta
Spinal Cord
Kidney
Air-bladder cut open
Spleen
Urinary Bladder distended
Urinary Aperture
Genital "
Anus
Intestine
Pyloric caeca
Stomach
Liver

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PLATE VII.—THE COD—*continued.*

INTERNAL ORGANS, EXOSKELETON AND ENDOSKELETON.

INTERNAL ORGANS—

FIG. 1. Frozen section (see details for freezing in case of Rabbit).

The object of this section is to show the various organs in their natural size and relation, and if taken in connection with fig. 2, Plate VI., where various parts are laid out to display their form, a good preliminary notion of the internal architecture will be obtained.

The drawing is a faithful copy of the section, with the exception of the brain, which was afterwards filled in from another section, the original being rather indistinct. In my first attempts at freezing, an ice-cream machine was used and the time allowed in the ice rather long, which seems to have had the effect of softening the brain, but the rapid and simple method afterwards followed with the Rabbit left the brain as hard as the other structures.

A *Codling* was used to suit size of Plate, and a tracing of the section made on glass and afterwards transferred to paper, thus ensuring absolute accuracy of size and outline.

The section was made a little to one side of the middle line, hence the anal, genital, and urinary openings are not seen. In addition to the points noted in fig. 2 of previous plate, the air-bladder may be specially mentioned.

Air-bladder.—Placed between kidneys and beneath spinal column, protected by wide transverse processes, and its inner surface raised into folds. As there is no duct for the passage of air from the alimentary canal, the air must pass in and out by the general surface of the bladder, including the rete mirabile.

From the relative positions of the stomach and bladder it may perhaps be inferred that when the stomach is full and distended it will compress the bladder, and so tend to make the fish heavier and sink; and when empty it will allow the bladder to expand, and so raise the fish. The Cod inhabits deep water, and feeds largely on mollusks and crabs, so the filling of the stomach will help it to remain at the bottom, just as in ourselves after a heavy dinner the diaphragm may be pushed against the lungs and so compress them.

Rete mirabile (L. wonderful net), a network of capillaries on inner surface of anterior end of bladder, formed by a branch of the cœliac artery, and forming a branch of mesenteric vein.

EXOSKELETON—

FIG. 2. Cycloid scale (Gr. *kuklos*, a circle) with concentric and radiating lines.

ENDOSKELETON—

FIGS. 3 and 4.

Atlas
- Centrum biconcave as in the majority of fishes and marked by concentric lines of growth.
- Transverse processes small, arising from centrum.
- Neural arch with articular facets and ending in neural spine.
- Articular surfaces for skull large and step-like.

FIG. 5. Ribs movably articulated with transverse processes, sometimes with extra ribs corresponding to uncinate processes in Reptiles and Birds (see Plate XV. fig 3).

FIG. 6. Hæmal arch formed by the ventrally united transverse processes.

FIG. 7. Tail called homocercal (Gr. *homoios*, like; *kerkos*, a tail), or equally lobed, in contradistinction to that found in Dog-fish, called heterocercal (Gr. *heteros*, different), or unequally lobed. On minute inspection it is found that in both these cases the notocord and with it the vertebral column is turned up, but in the one case the inferior arches coalesce to form hypural plate (Gr. *hupo*, under; *oura*, the tail), and the long and numerous fin-rays disguise the inequality of the lobes.

DIAGRAM 1 (from Gegenbaur's Comparative Anatomy).

The notocord is the primary axis of the body around which the bodies of the vertebræ are formed. As the vertebræ increase in size the notocord in the region *between* the vertebræ also grows, while the rest stops growing, hence it consists of alternate thick and thin portions. The bodies of the vertebræ are moulded upon this structure, and so become biconcave or *amphicoelous* (Gr. *amphi*, both; *koilos*, hollow). The gelatinous matter found between the vertebræ is the remains of the notocord, each concavity being connected by the slender portion of it, unless it has undergone ossification.

Fig. 2. Cycloid Scale

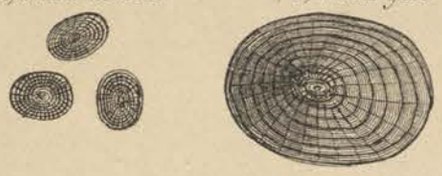

Fig 5. 6th Trunk Vertebræ
(Posterior View)

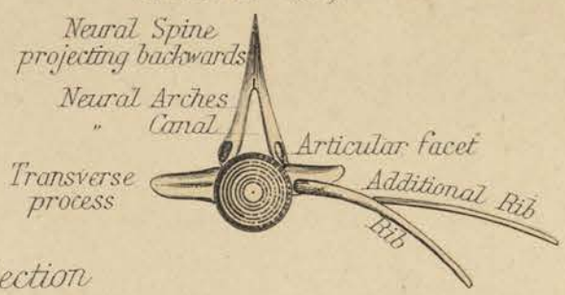

Fig 6. Caudal Vertebra
(Anterior View)

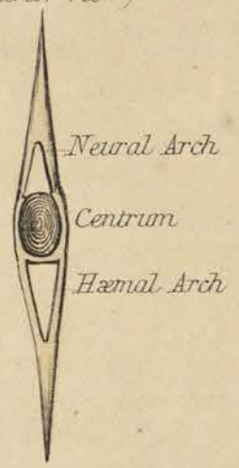

Fig. 1. Longitudinal Vertical Section with various organs in natural position

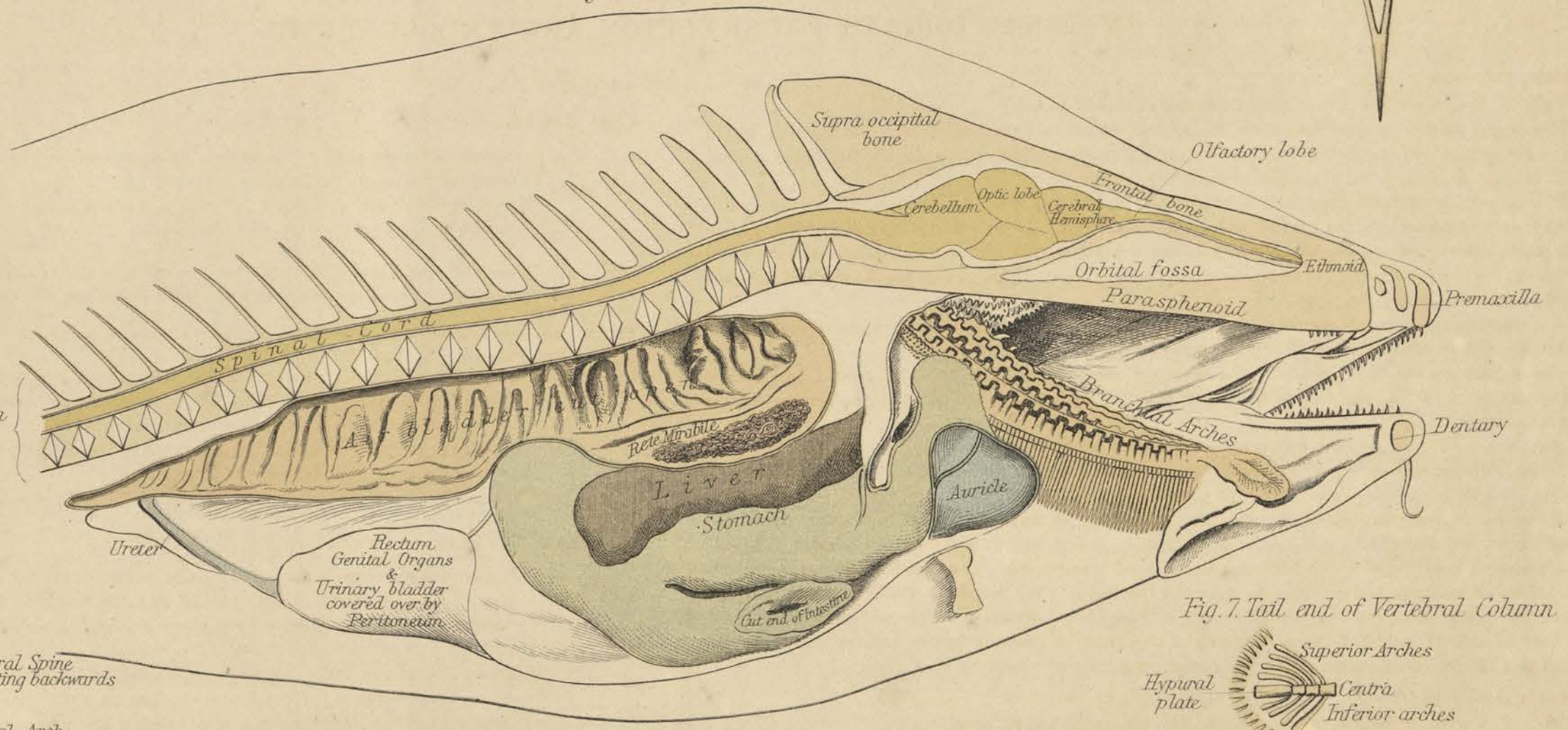

Fig. 3. Atlas
(Posterior View)

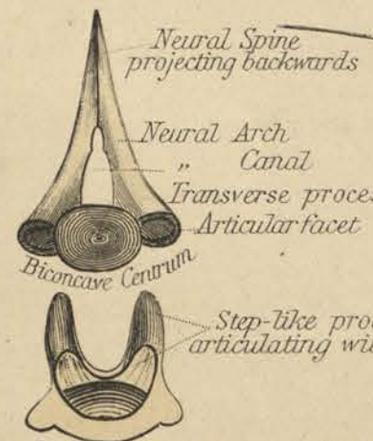

Fig. 4. Articular Surface of Atlas

Fig. 7. Tail end of Vertebral Column

Diagram 1. Longitudinal Section of 3 Vertebræ

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PLATE VIII.—THE COD—*continued.*

SKELETON AND NERVOUS SYSTEM.

SKELETON—*concluded*—

FIG. 1. Pectoral arch—
- Post-temporal attached to skull.
- Clavicle large, connected with its fellow in the middle line, and attached to post-temporal by a rod-like bone—the supra-clavicle.
- Scapula and coracoid adhering to inner face of clavicle and representing pectoral arch of skate.

Pectoral fin—
- Four basal bones, originally a fifth, but afterwards fused with upper fin-ray.
- Twenty fin-rays.

FIG. 2. Pelvic arch consisting of two bones connected in the middle line, each with a strip of cartilage interposed between the pelvic fin, which is composed of six fin-rays.

FIGS. 3 and 4. Skull may be readily prepared by putting a cod's head into boiling water and boiling for about half an hour. The various parts remain together as in fig. 3, and can be easily separated afterwards.

The bones of the skull may be grouped together as follows :—

Skull (cartilage bones or bones pre-formed in cartilage are distinguished by a lighter shade of colour from membrane or splint bones)—

Occipital segment (L. *occiput*, back of the head), (four bones) . . . . . :
- Basi-occipital with deep articular cup for atlas.
- Ex-occipitals, one on each side of foramen magnum.
- Supra-occipital, top bone projecting posteriorly as a median crest.

Parietal segment (L. *paries*, side of the head), (four bones) . . . . . :
- (Basi-sphenoid region (Gr. *sphen*, a wedge; *eidos*, shape), fibro-cartilaginous.)
- Ali-sphenoids, two side bones.
- Parietals, two top bones separated by the supra-occipital.

Frontal segment (L. *frons*, the forehead), (one bone) . :
- (Pre-sphenoid region, fibro-cartilaginous.)
- (Orbito-sphenoid region, fibro-cartilaginous.)
- Frontal composed of two bones fused together.

Para-sphenoid (Gr. *para*, beside), a long bone underlying the fibro-cartilaginous substance representing basi-sphenoid and pre-sphenoid.

Vomer (L. a ploughshare), connected with anterior end of para-sphenoid.

Pre-maxillæ, forming upper boundary of gape, and bearing teeth.

Maxillæ, above and behind pre-maxillæ, so that they do not enter into gape of mouth.

Region of nose (five bones) :
- Nasals overlying nasal sacs.
- Ethmoid in the middle line, terminating snout.
- Pre-frontals, or par-ethmoids, on either side.

Region of eye . . . . . :
- Lachrymal (L. *lachryma*, a tear), being anterior bone of the sub-orbitals, which form an incomplete ring about eye.

Region of ear (five bones) . :
- Pro-otic (Gr. *pro*, in front of; *ous*, *otos*, ear), notched for the passage of V. nerve.
- Opisth-otic (Gr. *opisthon*, behind), connected by suture with pro-otic.
- Epi-otic (Gr. *epi*, upon), forming a process behind.
- Pter-otic (Gr. *pteron*, a wing), forming outermost projection at back of skull.
- Parieto-frontal, post-frontal, or sphen-otic, projecting outwards from behind frontals.

Palato-quadrate arch (ten bones) . . . . . :
- Quadrate bone, with rounded articular surface for lower jaw.
- Meta-pterygoid, connected to quadrate by intermediate substance.
- Pterygoid connected by suture to meta-pterygoid.
- Meso-pterygoid, inside pterygoid.
- Palatine, connected with pterygoid and meso-pterygoid behind.

Symplectic (Gr. *sympleko*, I bind together) binding together hyomandibular and quadrate.

Mandible (six bones) . . :
- Articular, the ossified end of Meckel's cartilage, which cartilage will be seen to pass thence along inner side of dentary.
- Angular, forming a kind of corner or angle to articular.
- Dentary (L. *dens*, a tooth), bearing teeth.

Hyoid arch—
- Hyomandibular articulating with auditory capsule above, and closely united with symplectic and posterior edge of meta-pterygoid below.
- Remaining portion of arch consisting of stylo-hyal, epi-hyal, cerato-hyal with branchio-stegal rays (Gr. *stego*, I cover), hypo-hyal, glosso-hyal in front, and uro-hyal behind.

Operculum—
- Pre-opercular extending from hyomandibular to quadrate.
- Opercular joined to hyomandibular.
- Sub-opercular immediately beneath opercular.
- Inter-opercular connected by ligament to angular.

NERVOUS SYSTEM—

FIG. 5. Two brains used as in Skate—
- Olfactory lobes expanding at end.
- Cerebral hemispheres relatively small.
- Optic thalami, enclosing third ventricle. Pituitary body well developed.
- Optic lobes, represented by an imperfectly divided mass with—
- Inferior lobes and saccus vasculosus below.
- Cerebellum tongue-shaped.
- Medulla oblongata with swellings at the sides—restiform bodies.
- Optic nerves, large in accordance with large eyes, simply crossing each other.

FIG. 6. General distribution of V., VII., IX., and X. nerves in region of head and gills—
- V^1. Orbito-nasal above eye to nasal sacs and anterior region of head.
- V^2. Maxillary to upper jaw principally with its teeth.
- V^3. Mandibular to outer side of mandible, extending to barbule.
- VII^a. Palatine to roof of mouth.
- VII^b. Hyomandibular to hyoid arch, and sending a branch—chorda tympani—to inner side of mandible.
- IX. Glossopharyngeal divides into an anterior branch going to hyoid arch and pseudo-branchia, and a posterior branch to anterior face of first branchial arch.
- X. Pneumogastric supplying four branchial arches.

FIG. 7. Distribution of V. and X. nerves to various parts of body—
- V. Passing out by parietal in top of skull, and supplying all the fins, including pectoral and pelvic.
- Cutaneous branches along base of dorsal and ventral fins, terminating in a plexus which supplies caudal fin.
- Pectoral and pelvic branches to corresponding parts.
- X. Sending branches to lateral line, to junction of dorsal and ventral muscles, to stomach, heart, etc.

Fig. 1. Left half of Pectoral Arch with Pectoral Fin

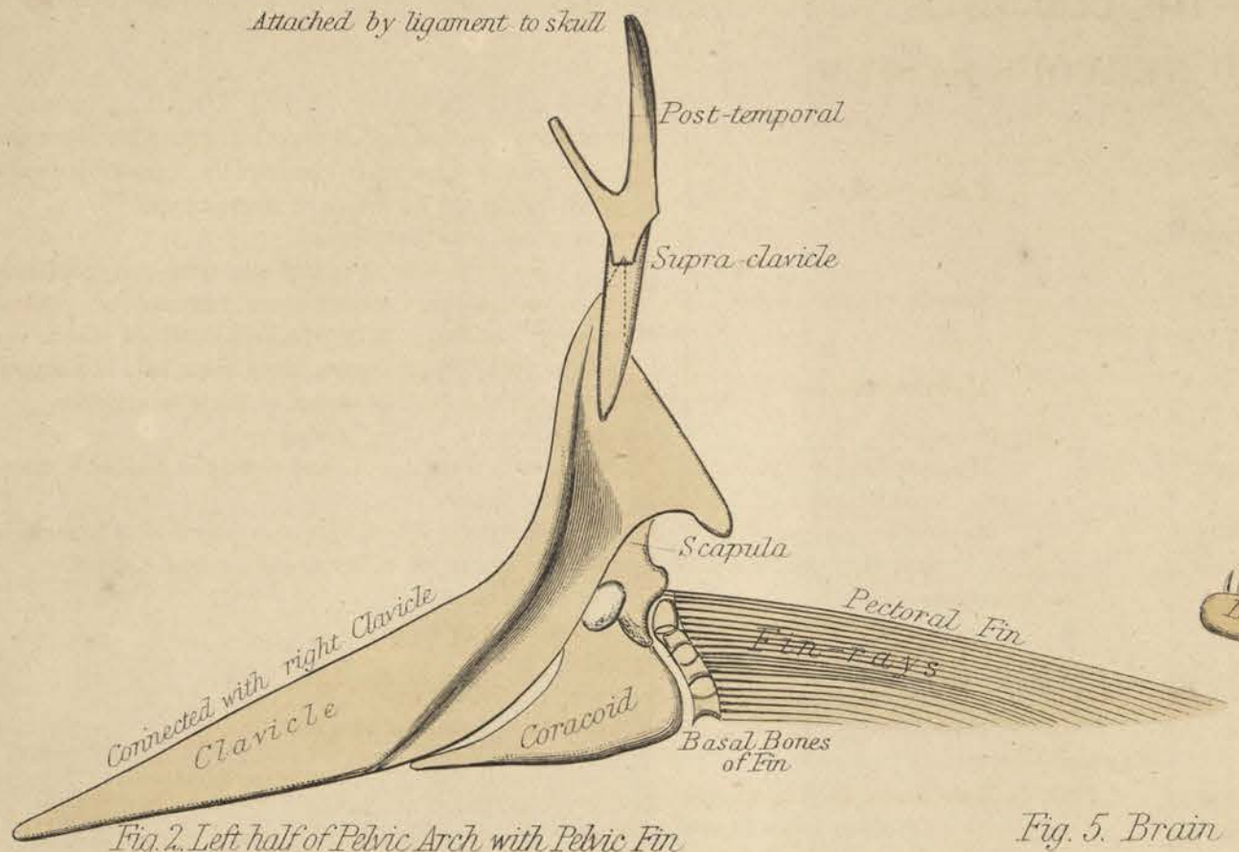

Fig. 2. Left half of Pelvic Arch with Pelvic Fin

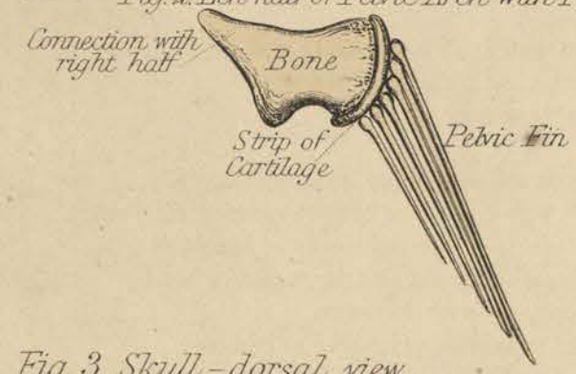

Fig. 3. Skull – dorsal view

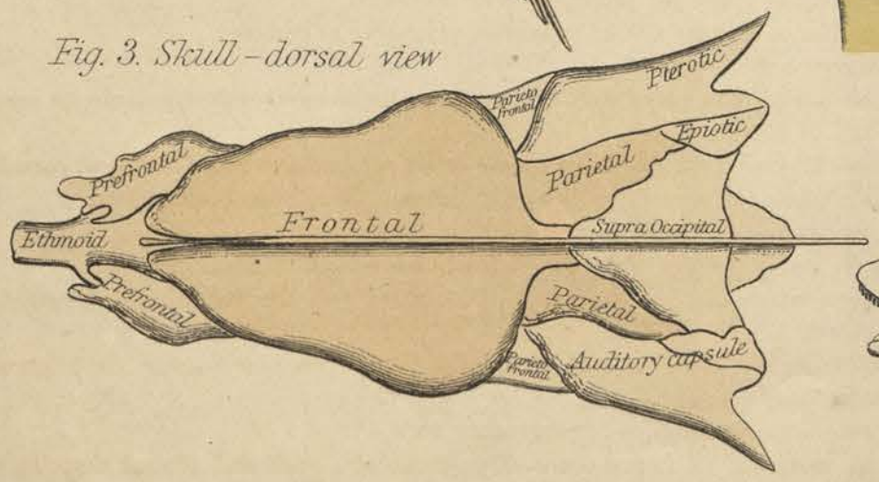

Fig. 4. Skull with bones disarticulated

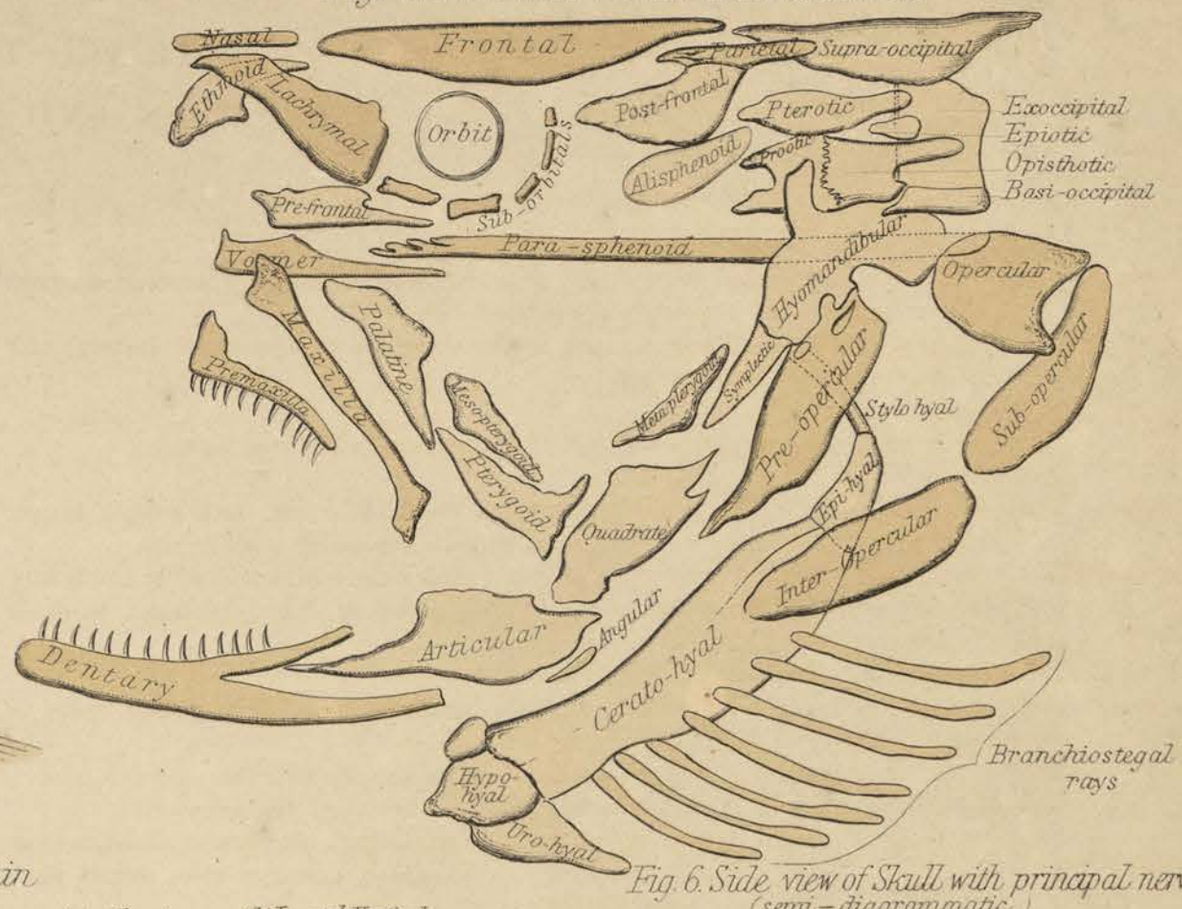

Fig. 5. Brain

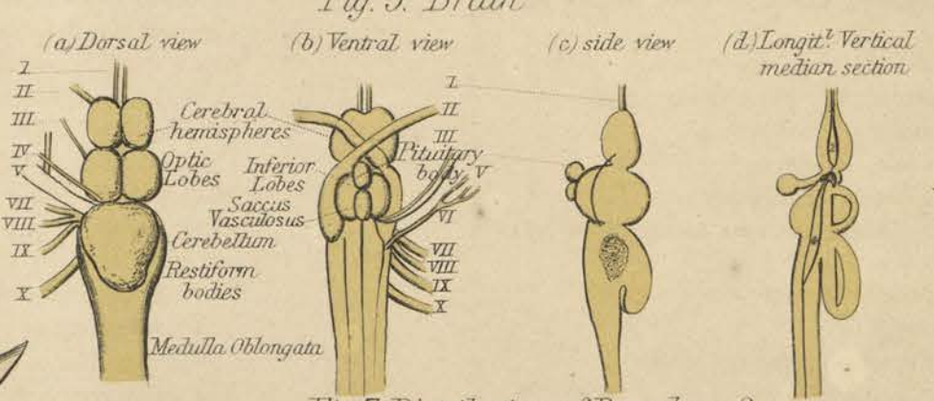

Fig. 6. Side view of Skull with principal nerves (semi – diagrammatic)

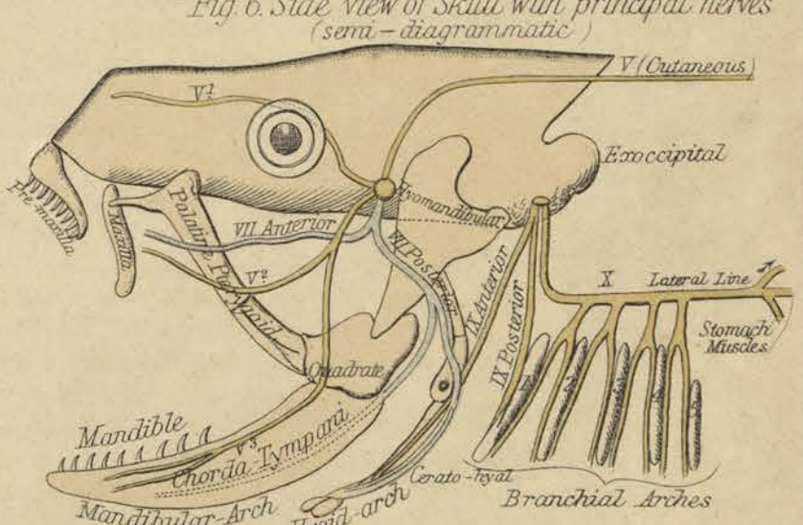

Fig. 7. Distribution of Branches of V. & X. Nerves

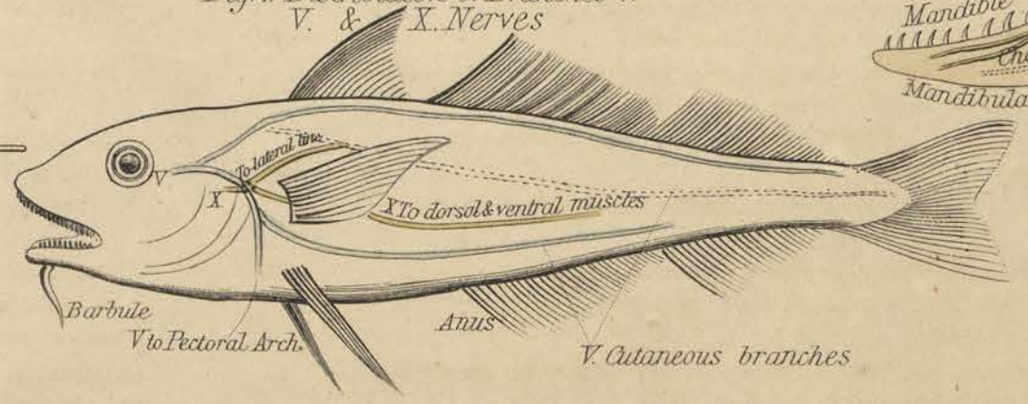

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PLATE IX.—THE COD—*concluded.*

SENSE-ORGANS, ALIMENTARY, CIRCULATORY, AND RESPIRATORY SYSTEMS.

SENSE-ORGANS—

FIGS. 1 and 2. Remove the eyes from right and left side. Place one with its corneal face downwards, and make a circular section midway (fig. 2); divide the other into a right and left half (fig. 1)—

Fibrous bands attach eye to wall of orbit.

Integument continued over cornea, eyelids being absent—conjunctiva.

Anterior chamber of eye (in front of lens) exceedingly small, and—

Iris lying close against its walls. (Chamber too large in drawing.)

Choroid gland near entrance of optic nerve.

Choroid passing into ciliary processes, and consisting of three layers—

Tapetum or silvery layer, continued upon iris.

Vascular layer.

Pigment layer, innermost and in close contact with rods and cones of retina.

Falciform process, extending from retina to lens. Like the pecten in birds, it appears to be the remains of the primitive infolding of the tissues which formed the vitreous humour.

Optic nerve, originally a *hollow* process from the brain, and the cleft extending from its entrance is the remains of this (fig. 2 *b*).

FIGS. 3 and 4. Membranous labyrinth, enclosed externally by bone, open internally—

Semicircular canals, large and readily made out. Anterior and posterior united at their origin, opening separately into vestibule by their ampullæ.

Calcareous otolith (Gr. *ous, otos,* the ear; *lithos,* a stone).

ALIMENTARY ORGANS—

FIG. 5. Rugæ (L. wrinkles), increasing the surface of stomach.

Pyloric cæca, a bundle of long slender pouches which open at commencement of intestine, and appear to perform the function of a pancreas.

FIG. 6. Cystic duct of gall-bladder, joining hepatic duct of liver, to open by a common bile-duct into commencement of intestine.

CIRCULATORY AND RESPIRATORY ORGANS—

FIG. 7. Heart—

Sinus venosus, relatively small, opening into auricle.

Auricle, thin walled.

Ventricle, very muscular.

Bulbus arteriosus, with muscular walls.

Principal arterial trunks—

Ventral aorta, giving off four branches on each side to the four functional branchial arches.

Dorsal aorta, arising from cephalic circle.

Principal venous trunks—

Duct of Cuvier, receiving anterior and posterior cardinal veins.

Anterior cardinal veins, right and left.

Posterior cardinal veins, right and left.

FIG. 8. Auriculo-ventricular valve, having two flaps.

Bulbus arteriosus, with two semi-lunar valves at base. This reduction to one transverse row of valves is in accordance with the absorption of the red portion or conus arteriosus of Skate into the ventricle.

FIG. 9 and DIAGRAM 1. Showing cephalic circle and branchial circulation (including pseudo-branchia and choroid gland).

Cephalic circle lies under base of skull, and is completed posteriorly by the transverse trunks uniting the efferent branchial vessels on each side to form dorsal aorta; anteriorly by a continuation of the same, uniting above para-sphenoid in the interior of the skull.

Principal arteries given off—

Brachial artery on each side.

Cæliac artery on one side.

Vessels to eye and nose from anterior part, and carotids from the side not shown.

Pseudo-branchia is a small oval red body inside each hyomandibular, covered with mucous membrane, representing the hyoid gill, but not functional as in the skate, hence it is supplied with arterial blood from the first branchial vessel.

A bifurcating trunk leaves it, one branch going to cephalic circle, the other (ophthalmic artery) breaks up in the choroid gland.

Choroid gland may represent the pseudo-branchia of skate, which is the rudimentary gill of mandibular arch.

CLASSIFICATION—

Sub-Kingdom—Vertebrata.

Class—Pisces.

Natural Order—Teleostei (Gr. *teleos,* perfect; *osteon,* bone)—

Skeleton bony.

Optic nerves simply cross and do not fuse.

No cloaca.

Heart with single row of valves in aortic bulb almost always.

Gills comb-like with gill-cover.

Family—Gadidæ.

Pelvic fins jugular.

Jaws and vomer with teeth.

Genus—Gadus.

Dorsal fins, three.

Barbule on lower jaw.

Species—G. morrhua.

Fig. 1. Horizontal section of Eye

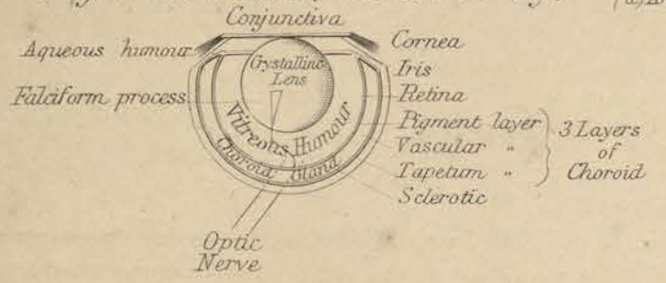

Fig. 2. Section of Eye parallel with Cornea

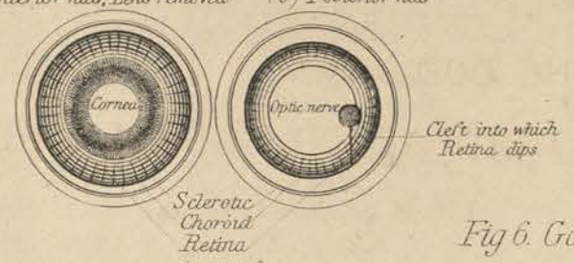

Fig. 3. Ear-Membranous Labyrinth

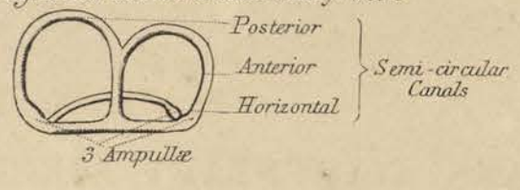

Fig. 4. Calcareous Otolith

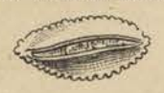

Fig. 5. Pyloric end of Stomach (laid open)

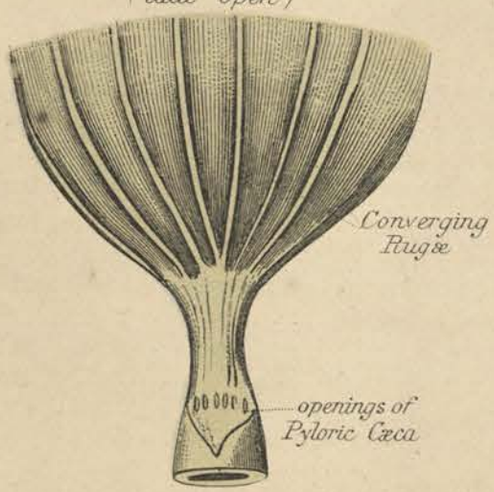

Fig. 6. Gall Bladder & Bileducts

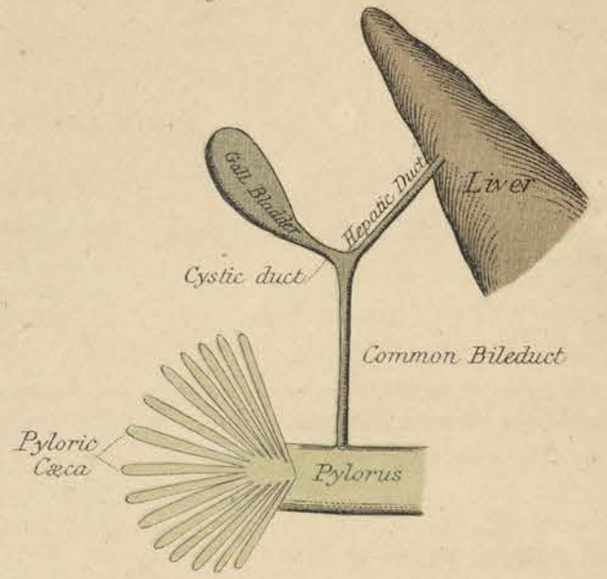

Fig. 7. Ventral view of Heart & Circulation. Branchial Arches of Left side shewn

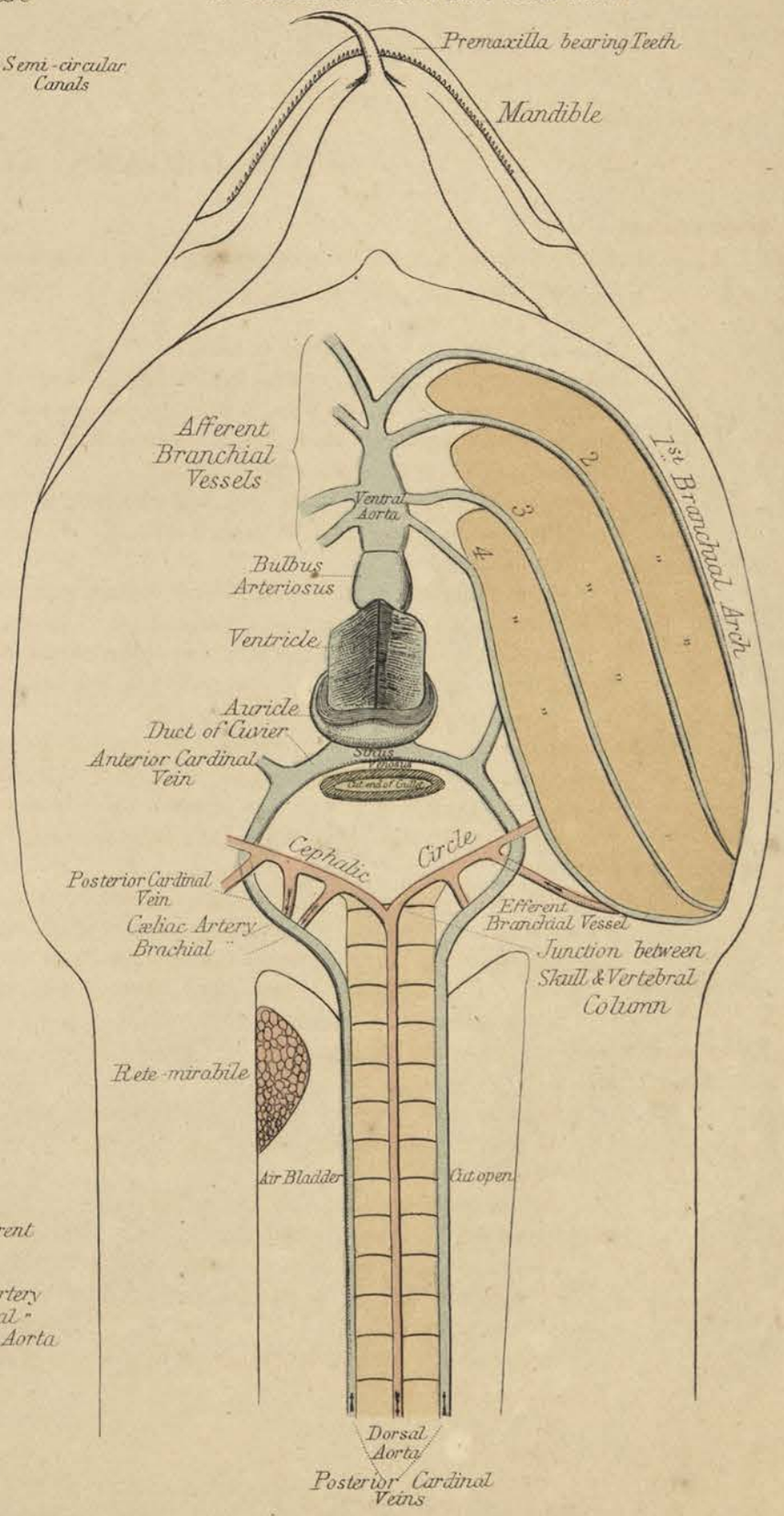

Fig. 8. Heart opened Ventrally

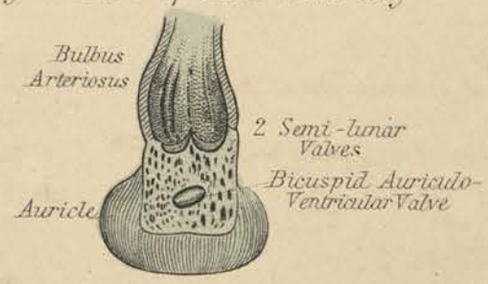

Diagram 1. Branchial Circulation & Cephalic circle. (side view)

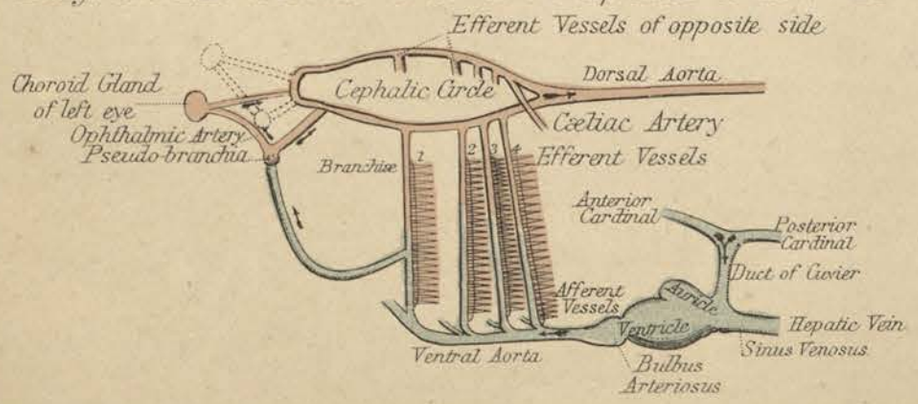

Fig. 9. Plan of Cephalic Circle

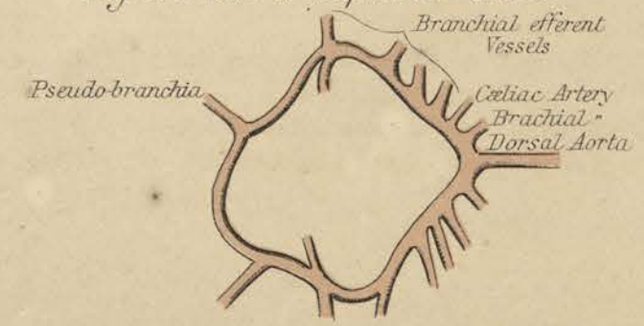

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PLATE X.—THE SALAMANDER.

EXTERNAL AND INTERNAL CHARACTERS.

The Land-Salamanders are not met with native in this country, but are distributed more particularly in the middle, western, and southern parts of Europe. They are often kept in greenhouses, where they lend a charm to the scene by their bright yellow patches of colour set on a deep black ground, and they prey upon the flies or the worms that are about. They are credited with being able to withstand the fire, owing to the vulgar notion that they could secrete enough of a watery fluid from their bodies to put the fire out.

Their average length is about six inches, exclusive of the tail, and they may be taken as an example of the tailed Amphibian when the Water Newts are not to be had.

Their lizard-like form is rather repulsive to some people, although they are perfectly harmless; and the feeling expressed in "Daniel Deronda" about the Blind-worm, a worm-like lizard, may be applied here: "We are rationally sure that the blind-worm cannot bite us mortally, but it would be so intolerable to be bitten, and the creature has a biting look—we decline to handle it."

EXTERNAL CHARACTERS—

FIG. 1. Mouth, with teeth on upper and lower jaw.
External nares (L. the nostrils).
Eye projecting.
Cutaneous glands, opening in rows on the wrinkled skin.
Fore-limb with four digits.
Hind-limb with five digits.
Cloaca on ventral surface—sides sensibly swollen in male.
Tail rounded.

INTERNAL ORGANS—

FIG. 2. Heart, consisting of ventricle and two auricles.
Lungs, a bag on each side.
Liver elongated.
Stomach and intestine.
Spleen adjoining stomach.
Kidney long and slender, accompanied by pro-renal duct.
Urinary bladder small.
Ovary studded with eggs.
Oviduct slender and convoluted.

SKELETON—

FIG. 3. Vertebral column, consisting of fifteen pre-sacral, one sacral, and about twenty-six caudal vertebræ.
Atlas or first vertebra, with two concavities for occipital condyles of skull.
Sacrum or sixteenth vertebra, specially modified to give attachment to pelvic arch.

FIG. 4. Sixth vertebra, the only one shown with rib attached—
Centrum opisthocœlous (Gr. *opisthen*, behind; *koilos*, hollow).
Transverse process, small and bifid at extremity.
Rib short, movably attached to transverse process, and bifurcating at free end.

FIG. 5. Sacral vertebra, showing—
Anterior zygapophysis (Gr. *zugos*, a yoke; *apophusis*, a process), or pre-zygapophysis, the articular surface for preceding vertebra.
Posterior zygapophysis, or post-zygapophysis, for succeeding vertebra.

FIG. 6. Pectoral arch—
Scapula and supra-scapula—dorsal.
Coracoid and pre-coracoid—ventral.
Glenoid cavity for humerus.

FIG. 7. Fore-limb—
Humerus or arm-bone.
Radius and ulna, or bones of forearm, separate.
Manus (L. hand):
- Carpus (Gr. *carpos*, wrist):
  - Proximal row—Radiale, intermedium and ulnare fused.
  - Centre—Centrale.
  - Distal row—Four carpalia.
- Metacarpus—Four metacarpals.
- Digits—Four, each composed of joints or phalanges.

FIG. 8. Pelvic arch—
Ilium rib-like, articulating with sacrum.
Ischium (Gr. *ischion*, the hip), posterior.
Pubis anterior to ischium, with a median forked portion proceeding from symphysis (Gr. *sun*, together; *phusis*, growth).
Acetabulum or socket for head of thigh-bone.

FIG. 9. Hind-limb—
Femur or thigh-bone. Tibia and fibula, or leg bones, separate.
Pes (L. foot):
- Tarsus:
  - Proximal row—Tibiale, intermedium, fibulare.
  - Centre—Centrale.
  - Distal row—Five tarsalia.
- Metatarsus—Five metatarsals.
- Digits—Five.

FIG. 10 (From Gegenbaur's Comparative Anatomy) and FIG. 11. Showing the change of skeleton consequent upon change of life. The hyoid arch remains, and portions of the first and second gill-arches.

FIG. 12. Dorsal view of skull—
Parietals united. Frontals united, but separate from parietals. Nasals paired. Pre-maxillæ, each sending a backward process to nasal. Maxillæ, extending to jugal. Quadrato-jugal, represented by fibrous tissue, the quadrate portion articulating with lower jaw. Squamosal supporting tympanum. Pterygoid meeting palatine inferiorly.

FIG. 13. Ventral view—
Ex-occipitals, each bearing a condyle. Para-sphenoid. Palatines bearing teeth. Vomers, paired.

FIG. 14. Dentary bearing teeth. Articular forming articular surface.

NERVOUS SYSTEM—

FIG. 15. Brain very small, note on upper surface—
Cerebral hemispheres showing separation.
Optic lobes with optic thalami in front and small cerebellum behind.
Medulla oblongata passing into spinal cord.

ALIMENTARY SYSTEM—

FIG. 16. Stomach, a dilatation of the gullet.
Small intestine with duodenal portion next to stomach.
Rectum (L. the seat) opening into cloaca.
Liver with gall-bladder in a notch at posterior end.
Pancreas elongated.
Spleen in region of stomach.

RESPIRATORY SYSTEM—

FIG. 17. Glottis (Gr. *glotta*, tongue), the entrance to larynx.
Larynx represented by arytenoid cartilages.
Trachea, short and membranous, branching to each lung.
Lungs with infoldings on the inner surface producing shallow depressions.

FIG. 18.

CIRCULATORY ORGANS—
Right and left auricles. Ventricle. Four aortic arches on each side—first, or inner, giving off carotid; fourth, or outer, giving off pulmo-cutaneous. Dorsal aorta supplying genital and urinary organs as well as body generally.

URINO-GENITAL ORGANS—
Pro-renal duct receiving the ureters and opening into cloaca. Kidney proper receives the vasa efferentia (L. efferent ducts) of testis, and the ureters open into pro-renal duct. Testis consisting of two connected divisions.

CLASSIFICATION—

Sub-Kingdom—Vertebrata.
Class—Amphibia—
Skull, with two occipital condyles. Cloaca. Heart three-chambered. Gills in early life, afterwards lungs.
Natural Order—Urodela (Gr. *oura*, a tail; *delos*, distinct)—
Body elongated, with relatively short limbs. Tail permanent. Bones of fore-limb (radius and ulna) and bones of hind-limb (tibia and fibula) separate. Mandible always bears teeth.
Family—Salamandridæ (including Triton or Water-Salamander, and Salamandra or Land-Salamander).
Genus—Salamandra.
Species—S. maculosa (L. *maculosus*, spotted).

Fig 1. Dorsal Surface of Female

Fig 2. Dissection from Ventral Surface Right Ovary removed

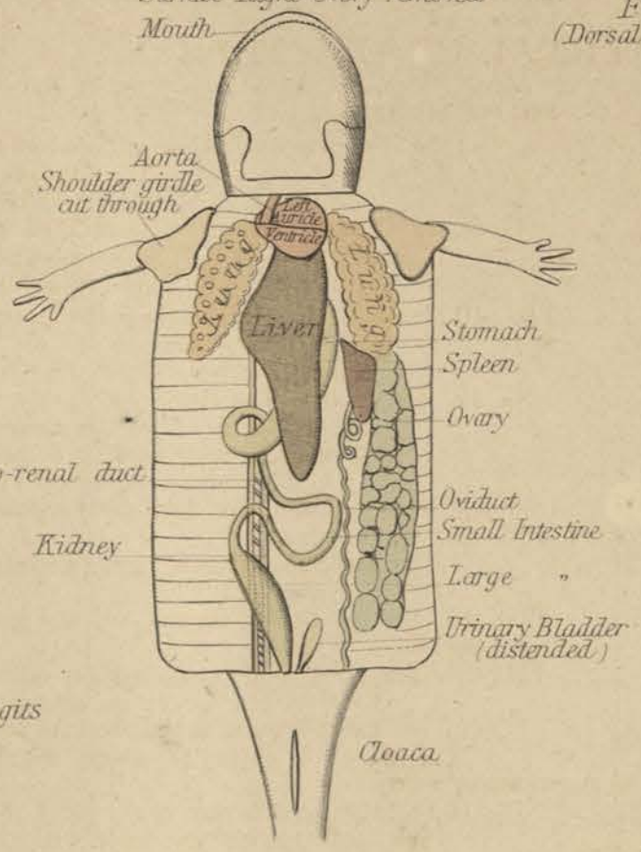

Fig 3. Vertebral Column
(Dorsal view) Caudal Vertebræ not shown

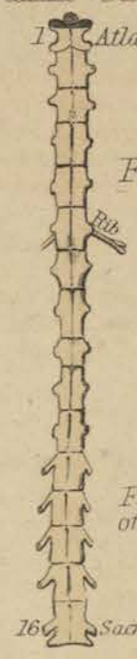

Fig 4. Side View of 6th Vertebra

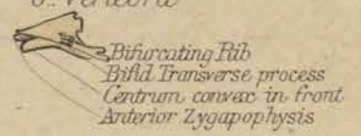

Fig 5 Ventral View of Sacral Vertebra

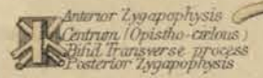

Fig 6. Pectoral Arch
Ventral View of left half

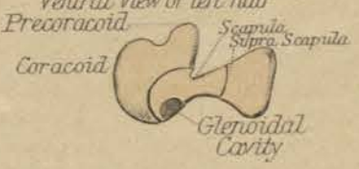

Fig 7. Right Fore-limb

Fig 8. Pelvic Arch
(Ventral View)

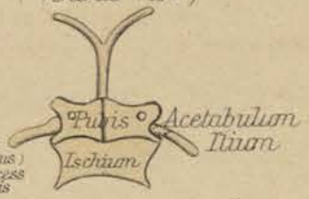

Fig 9. Right Hind-limb

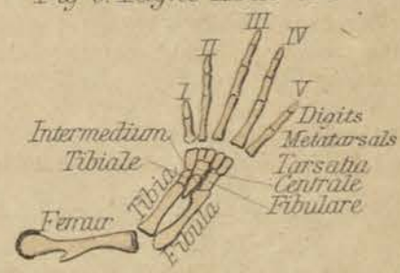

Fig 12. Skull
(dorsal View)

Fig 13. Skull
(Ventral View)

Fig 14 Ramus of Mandible

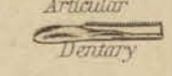

Fig 10. Hyo-branchial of gill bearing Larva

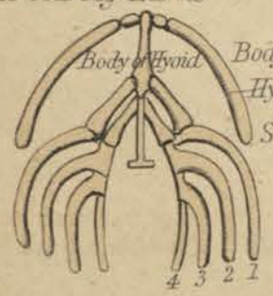

Fig 11. Hyobranchial of Adult

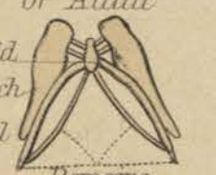

Fig 15. Brain in Brain Case
(Dorsal Surface)

Fig 16. Alimentary Canal with Appendages

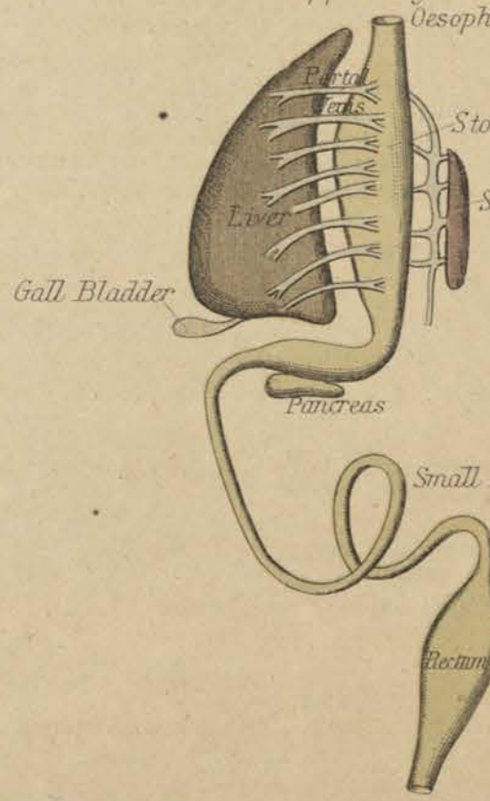

Fig 17. Respiratory Organs

Fig 18. Circulatory & Urinogenital Organs

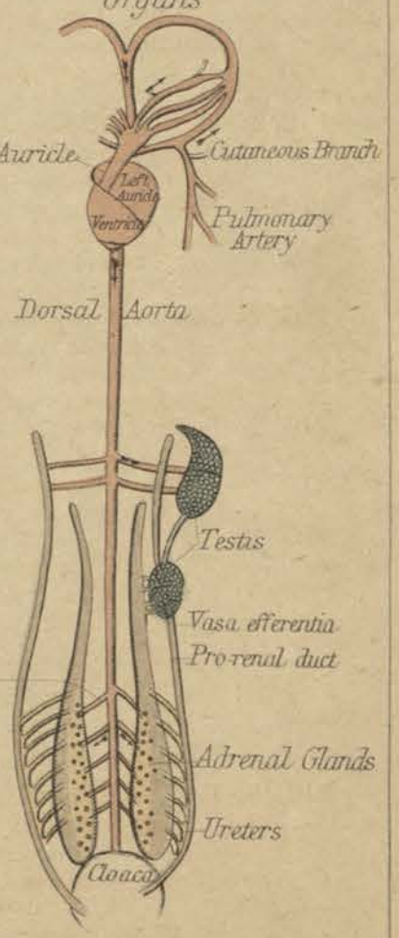

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PLATE XI.—THE TORTOISE.

EXTERNAL AND INTERNAL CHARACTERS.

The Tortoise belongs to the class of Reptiles which includes also Lizards, Snakes, and Crocodiles, and this familiar form has been chosen simply because it is of convenient size and may be procured from naturalists. The reptilian type of structure is very varied, allied to the Amphibian on the one hand and to the Bird on the other, hence it is hardly possible to make any single form do duty for the whole. However, the study of the Tortoise is a fit starting-point for the understanding of the whole group, seeing that it closely resembles and is yet clearly distinguishable from the Amphibians in organization.

EXTERNAL CHARACTERS—

FIG. 1. Body enclosed in a bony case into which head, tail, and limbs can be retracted.
Head passing gradually into neck.
Horny beak at anterior end of head, and eyes at side.
Tail flexible.
Fore-limb with five digits.
Hind-limb with four digits and rudimentary fifth.
Epidermal horny plates arranged in median, lateral, and marginal series dorsally, with six pair ventrally (fig. 4).

INTERNAL ORGANS—

FIG. 2. Kill by putting cotton wool soaked with chloroform into its mouth. Carefully remove the ventral shield by sawing it through lengthways on both sides, and dissect away pectoral and pelvic muscles to expose internal organs.

Pleuro-peritoneal cavity, the pleura not being separated from the peritoneum as in man:
- Heart consisting of ventricle and two auricles.
- Trachea, or windpipe, dividing into two bronchi.
- Lungs, one on each side fastened to the dorsal wall of cavity.
- Liver, broad, with gall-bladder embedded in right lobe.
- Alimentary canal ending in cloaca.
- Urinary bladder very large.
- Ova orange-coloured and spherical.
- Oviduct much convoluted.

Cloacal aperture near end of tail.

Carapace and Plastron.—After boiling the shell, the attachment between the horny epidermal plates and the bony plates beneath is loosened, and the former may be easily detached with a blunt knife.

DIAGRAM 1. Carapace, or dorsal covering, consisting of three series of bony plates . . . .
- Neural plates, or expanded spines of dorsal vertebræ.
- Costal plates, or expansions of dorsal surface of ribs.
- Marginal plates at free end of ribs.

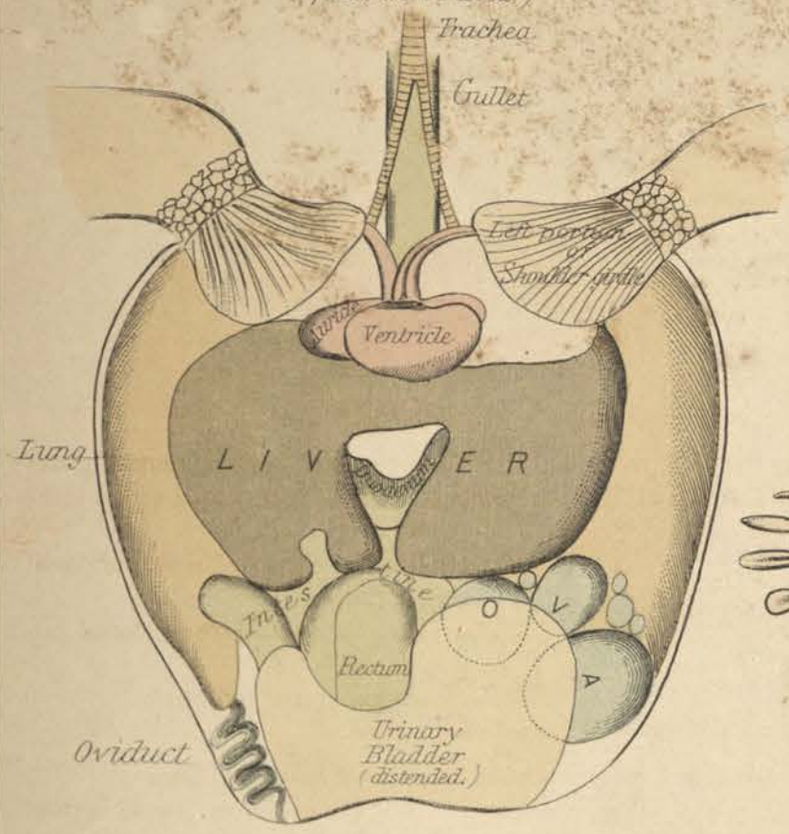
Plastron, or ventral covering, consisting of dermal ossifications.

FIGS. 3 and 4. The markings of the detached epidermal plates are shown as distinct lines—

Carapace . . .
- Median plates—eight neural, with nuchal plate (L. *nucha*, the neck) in front and pygal plates (Gr. *puge*, the rump) behind.
- Lateral plates—eight costal.
- Marginal plates—eleven.

Plastron, nine plates . .
- Median plate—Ento-plastron.
- Lateral plates, meeting in middle line—Epi-plastron.
  Hyo-plastron.
  Hypo-plastron.
  Xiphi-plastron.

Fig. 2. Dissection from Ventral surface (plastron removed.)



Pelvic Region

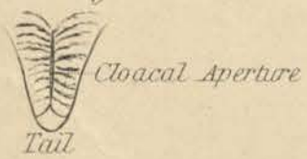


Diagram 1. Transverse section of Carapace & Plastron

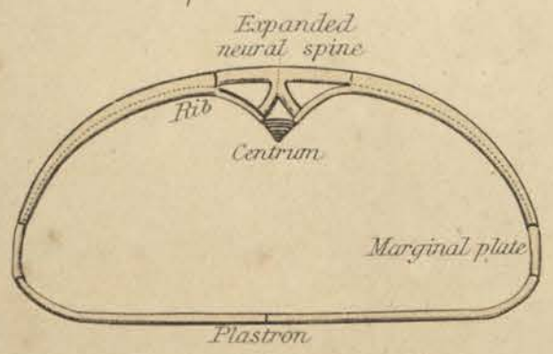


Fig. 1. Dorsal View

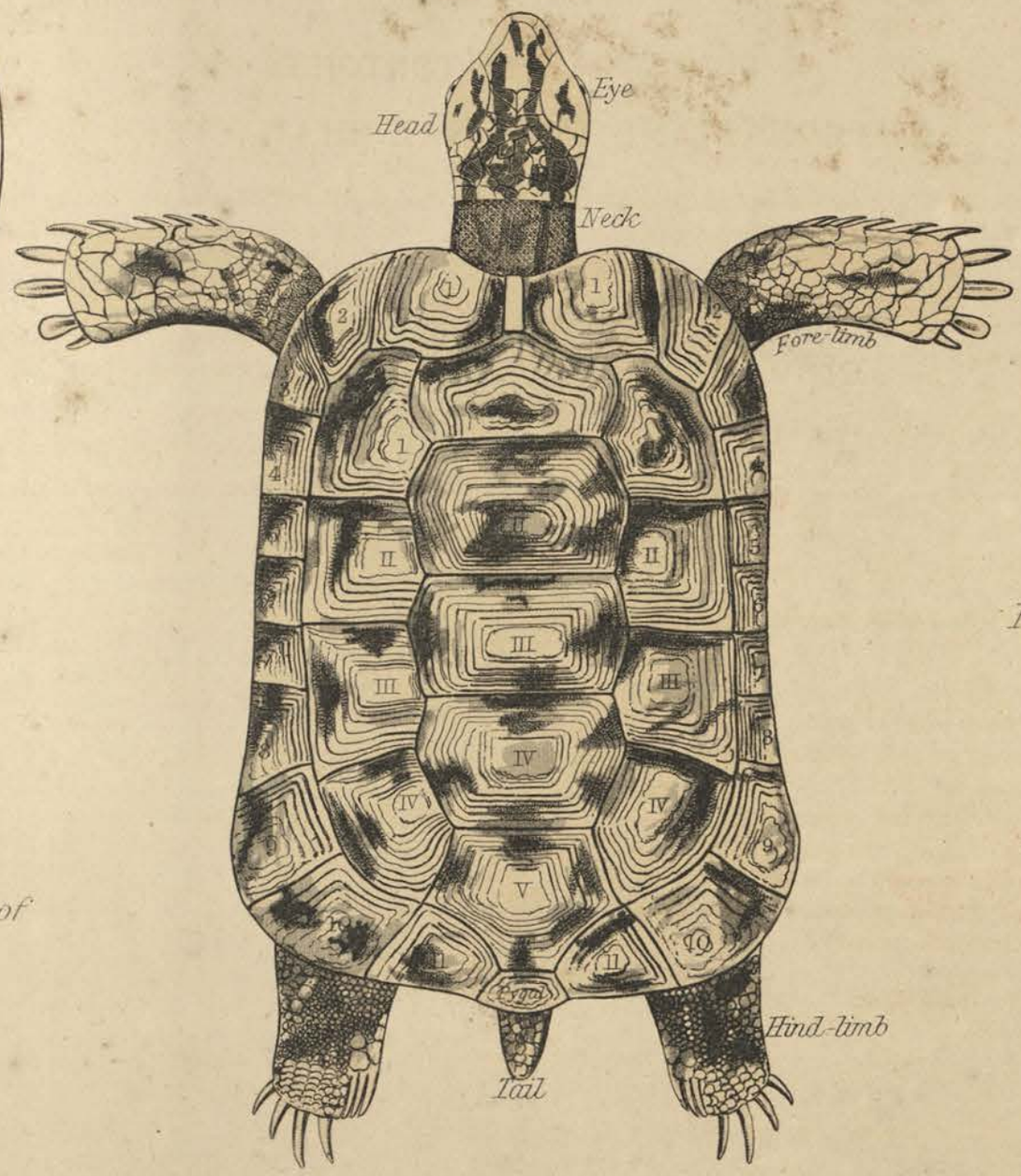


Fig. 3. Carapace – Epidermal Plates removed

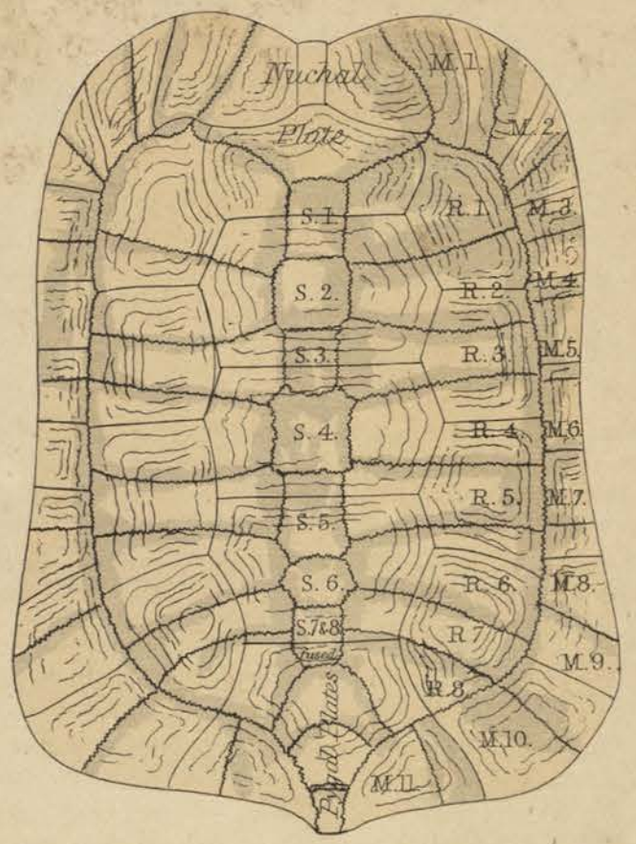


Fig. 4. Plastron covered by Epidermal Plates

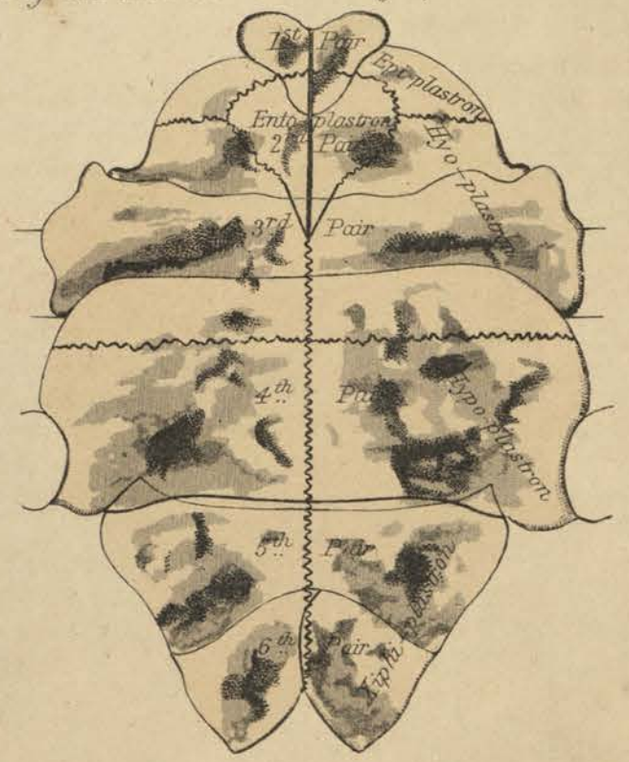


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PLATE XII.—THE TORTOISE—*continued.*

SKELETON, NERVOUS AND SENSE ORGANS, ALIMENTARY SYSTEM.

SKELETON—*concluded.*

FIG. 1. The cervical and caudal vertebræ may be detached, but the dorsal are firmly fixed inside shell.

Cervical vertebræ, eight, freely movable—

Atlas, consisting of a basal portion and two sides, connected by a transverse ligament.

Axis—centrum with odontoid process, which is the centrum of atlas separately ossified and attached to axis.

Eighth playing freely up and down upon first dorsal.

Dorsal vertebræ, ten, fixed—

First—Spine not expanding into neural plate, and rib forming no costal plate.

Second to ninth—Spines expanding into neural plates (S. (spines) 1-8), and slender ribs fixed and expanding into costal plates (R. (ribs) 1-8).

Tenth—Rib forming no costal plate.

Sacral vertebræ, two, giving attachment to ilium by ribs.

Caudal vertebræ movable. The tail is scarcely as long as the neck, although containing more than twice the number of vertebræ.

FIG. 2. Pectoral arch—

Scapula vertical, and attached by ligament to first costal plate.

Coracoid articulating with scapula to form glenoid cavity.

Epi-coracoid at ventral end of coracoid.

Pre-coracoid forming one bone with scapula.

Fore-limb—

Humerus much twisted.

Radius and ulna, the latter stoutest.

Manus . { Carpus . { Proximal row—Radiale, intermedium, and ulnare. / Centre—Centrale. / Distal row—Four carpalia, first and second having fused. } / Metacarpus—Five metacarpals supporting as many digits. / Digits—Short and clawed, each consisting of two phalanges. }

FIGS. 3 and 4. Pelvic arch—

Ilium, vertical and somewhat resembling scapula, attached to sacral ribs.

Ischium, meeting with its fellow in a ventral symphysis.

Pubis large, and forming a long symphysis with its neighbour.

Obturator foramen (L. *obturo*, I close up) oval, between ilium and ischium.

Acetabulum, a socket at the junction of the three bones.

Hind-limb—

Femur, slightly curved.

Tibia and fibula.

Pes . { Tarsus { Proximal row—Tibiale, intermedium, and fibulare united. / Centre—Centrale, united to preceding. / Distal row—Four tarsalia, the fourth and fifth having fused. } / Metatarsus—Five metatarsals. / Digits—Five, the fifth having one joint, the others two. }

FIG. 5. Dissect out hyoid at base of tongue, with anterior and posterior processes—

Body or basi-hyal, a broad plate.

Anterior processes, or cerato-hyals, not connected with skull as in the frog.

Posterior or branchial processes, called "thyro-hyals."

FIG. 6. Dorsal view—

Supra-occipital, with median backward-projecting crest.

Parietals forming a median ridge, and descending on each side.

Frontals relatively large.

Pre-maxillæ, united and small.

Squamosal above quadrate.

Quadrato-jugal, and jugal connecting quadrate with maxilla.

Ventral view—

Basi-occipital, with single occipital condyle.

Basi-sphenoid.

Quadrate stout, and fastened to outer side of ear-capsule.

Pterygoid connected behind with quadrate, in front with palatine, and inwardly united with its fellow.

Palatine bounding posterior nostril in front.

Vomer median.

Mandible—All in one piece, with dentaries sheathed in horn, which is finely toothed on upper edge (not shown).

NERVOUS AND SENSE ORGANS—

FIG. 7. Brain, natural size and enlarged—

Olfactory lobes marked off from cerebral hemispheres by a fissure.

Cerebral hemispheres, oval smooth bodies.

Optic thalami, with pineal gland above and pituitary body below.

Optic lobes fully exposed on top.

Cerebellum fissured in the median line.

Medulla oblongata.

FIG. 8. Eyeball, showing optic nerve entering sclerotic outside of optic axis.

FIG. 9. Section showing—

Convex cornea.

Crystalline lens somewhat flattened anteriorly.

Anterior termination of retina (retina coloured yellow).

FIG. 10. Sclerotic ring of small bony plates at junction with cornea.

FIG. 11. Tympanic membrane covered externally by integument.

Columella auris or stapes attached to membrane, and extending to fenestra ovalis.

ALIMENTARY SYSTEM—

FIG. 12. Alimentary canal about four times the length of the body.

Gullet dilating into stomach.

Small intestine opening obliquely into first part of large intestine or colon.

Large intestine ending in cloaca.

Portal vein receiving branches from pancreas and spleen and entering liver.

Fig. 1 Vertebral Column
(Ventral View)

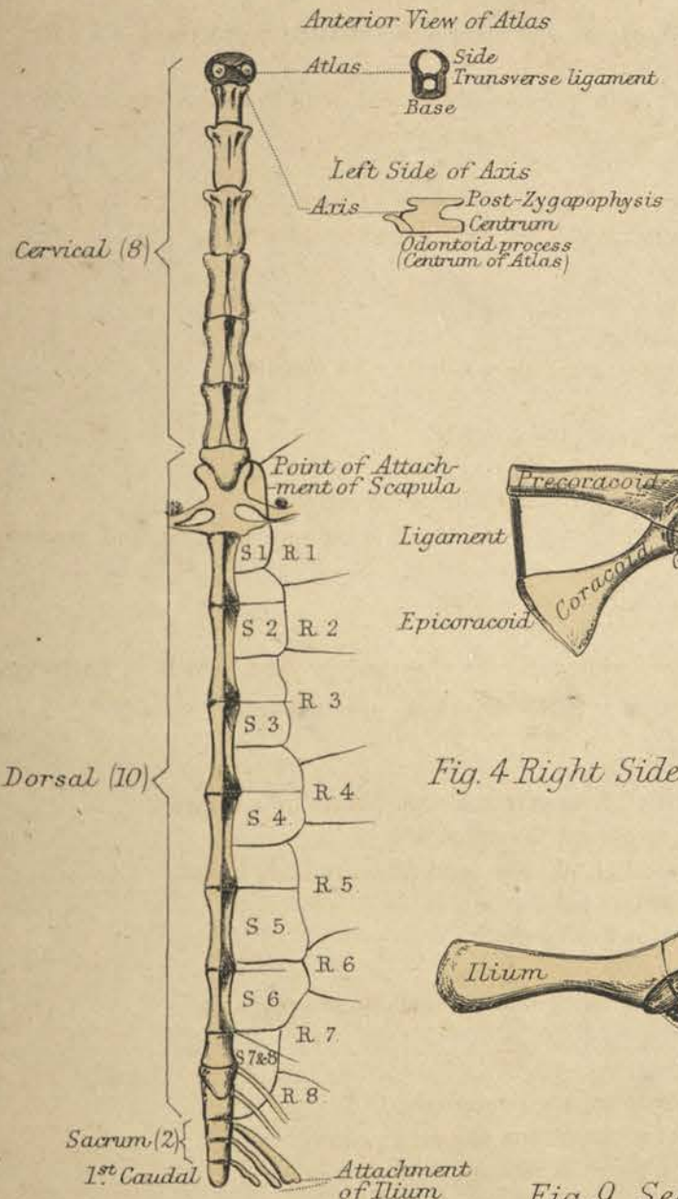

Fig. 5 Hyo-branchial

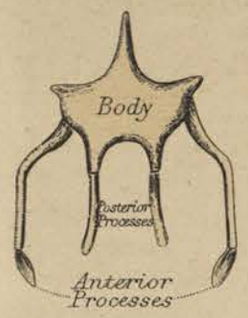

Fig. 2 Left side of Pectoral Arch with left Fore-limb

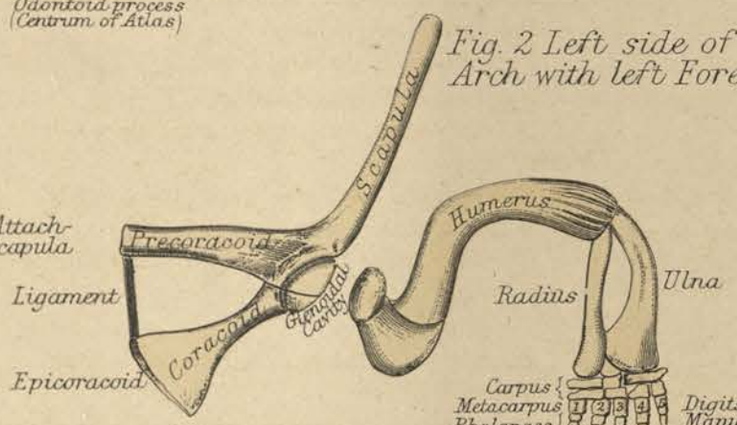

Fig. 3 Pelvic Arch & Left Hind-limb

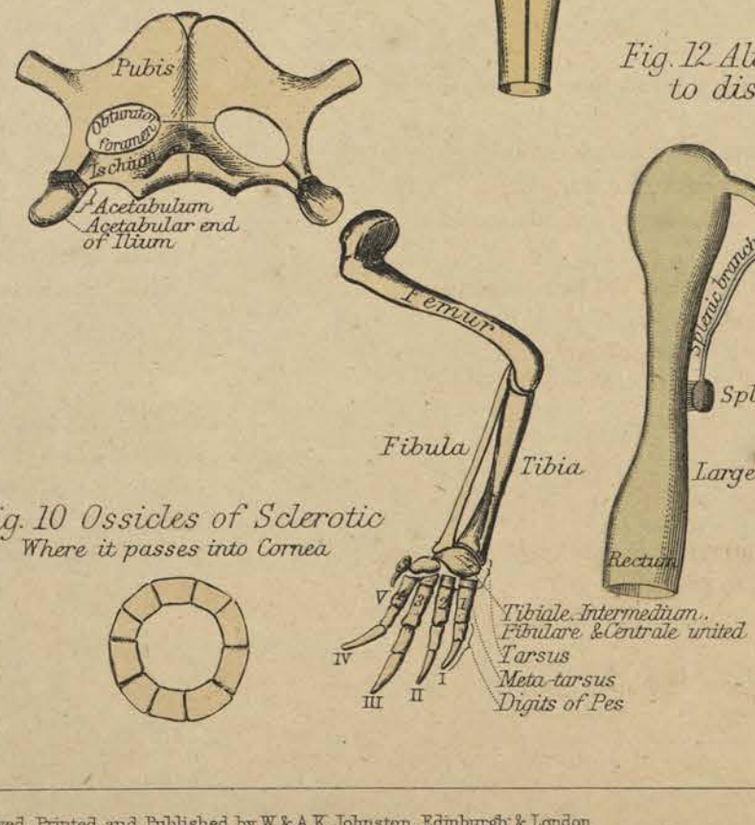

Fig. 4 Right Side of Pelvis

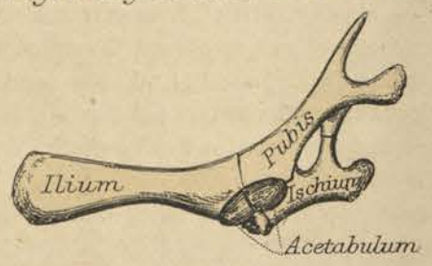

Fig. 6 Skull

Fig. 7 Brain

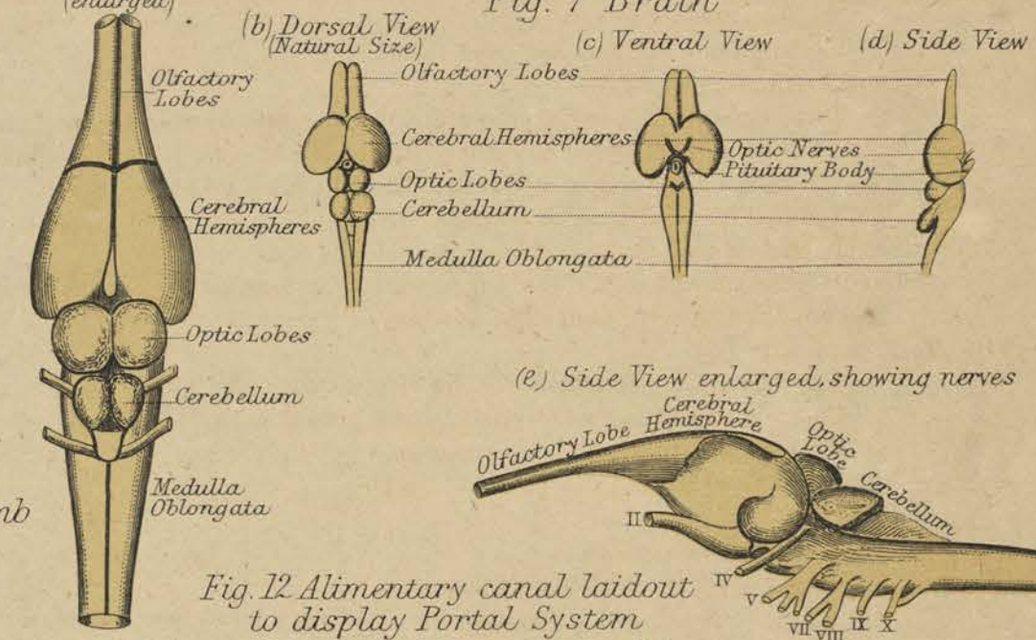

Fig. 8 Eye-ball removed

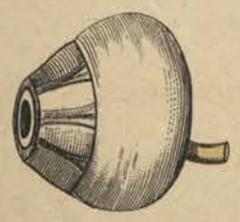

Fig. 9 Section of Eye

Fig. 10 Ossicles of Sclerotic
Where it passes into Cornea

Fig. 12 Alimentary canal laidout to display Portal System

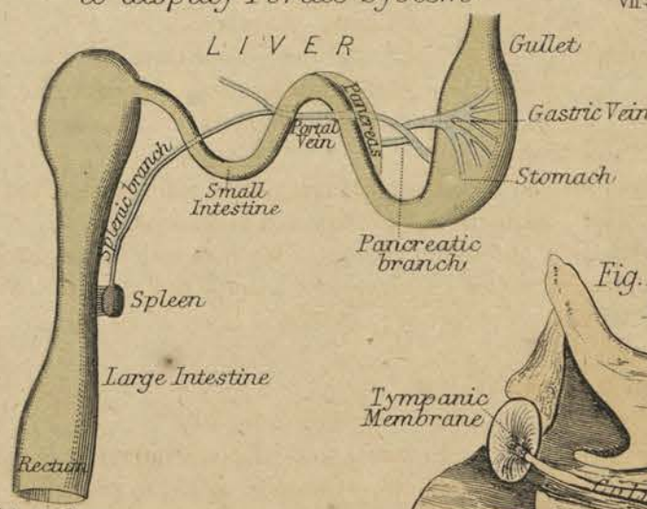

Fig. 11 Section of Auditory Portion of Skull

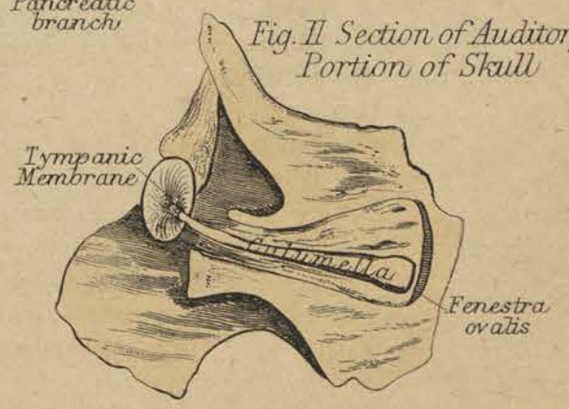

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PLATE XIII.—THE TORTOISE—*concluded.*

ALIMENTARY, CIRCULATORY, RESPIRATORY, AND URINO-GENITAL ORGANS.

ALIMENTARY SYSTEM—*concluded.*

FIG. 1. Showing one of the hepatic ducts passing directly to duodenum.

CIRCULATORY SYSTEM—

FIG. 2 and DIAGRAM 1.

Heart . . . . . { Sinus venosus, opening into right auricle.
Right and left auricles, separated by a septum, the free edges of which form auriculo-ventricular valve.
Ventricle, broader than long.

Principal arteries . { Right aorta, giving off brachial to fore-limb and carotid to head.
Left aorta, giving off cæliaco-mesenteric to viscera, then joining right to form Dorsal aorta.
Pulmonary, dividing for each lung.

Principal veins . . { Right and left superior and inferior venæ cavæ.
Pulmonary, from each lung, opening by a common trunk into left auricle.

DIAGRAM 1. *Working of Heart.*—Sinus venosus contracts and drives *venous* blood into *right* auricle, the *left* auricle receiving *arterial* blood from pulmonary vein. The two auricles contract simultaneously and drive their blood into the ventricle. The purely venous blood passes into the three vessels, but mainly into the pulmonary artery; and as the pressure becomes equal on both sides of the muscular septum, the supply is cut off before the arterial blood has reached the pulmonary artery. Next the mixed venous and arterial blood enters the left aorta, and the residue, which is pure arterial blood, partly supplies left aorta, but mainly right aorta, for the use of the head. Thus entirely venous blood goes to the lungs, mainly mixed blood to the left aorta, and latterly pure arterial blood to the right aorta (right side of ventricle contains venous blood at first).

FIG. 3. Red corpuscles, oval and nucleated.

RESPIRATORY SYSTEM—

FIG. 4. Larynx—Arytenoid cartilage at each side.
Crico-thyroid cartilage circular, with projections at side.
Trachea, with cartilaginous rings, and dividing into bronchi which are longer than trachea.

URINO-GENITAL SYSTEM—

FIG. 5. Kidney, sponge-colour, and surface convoluted.
Ureter, alongside vas deferens, ending in urino-genital sinus formed by neck of bladder.
Testis oval, with vas deferens convoluted in its upper part, forming epididymis.
Penis grooved on dorsal surface.

FIG. 6. Ovary, containing ova of a blood-orange colour.
Oviduct, consisting of an anterior convoluted oviducal or Fallopian portion, opening by a wide mouth, and a posterior dilated or uterine portion.

FIG. 7. Rectum and bladder opening close together.
Ureters and oviducts opening close to neck of urinary bladder.

FIG. 8. Calcareous egg-shell secreted in uterus.

CLASSIFICATION—

Sub-Kingdom—Vertebrata.

Class—Reptilia—
Skull with single occipital condyle.
Mandible articulating with quadrate and not directly with skull.
Cloaca.
Heart three-chambered (in Crocodile four-chambered).
Visceral arches never bear gills.

Natural Order—Chelonia (Gr. *chelone*, a Tortoise)—
Carapace and plastron.
Dorsal vertebræ immovable, and ribs immovably fixed to them.
Jaws without teeth, encased in horn.

Family—Testudinidæ (L. *testudo, testudinis*, a Tortoise)—
Limbs with stumpy feet adapted for progression on land.

Genus—Testudo.

Species—T. Græca, because found native in Greece.

Fig. 1 Right Lobe of Liver
(Dorsal Surface)

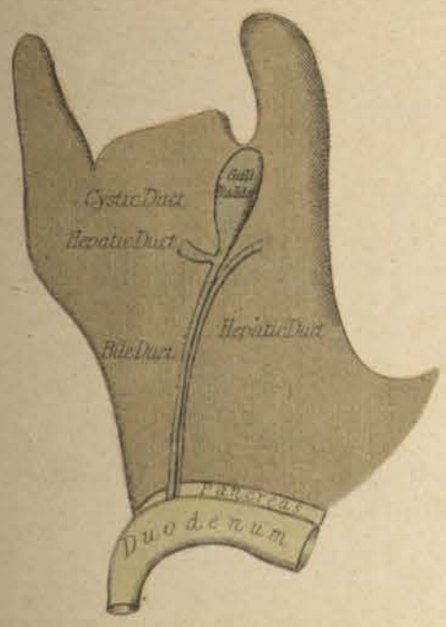

Fig. 2 Heart & Great Vessels
(Ventral View)

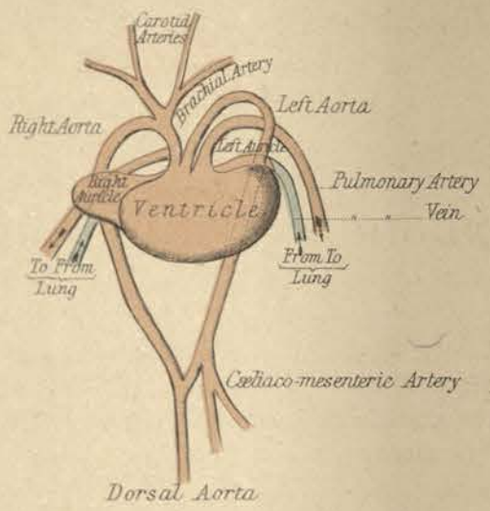

Diagram 1. Essential structure of Heart

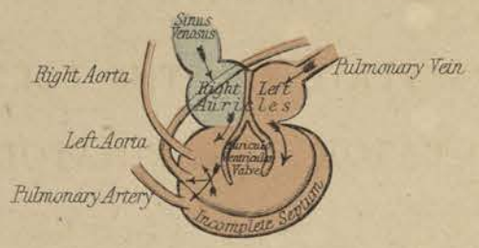

Fig. 3 Red Blood Corpuscles

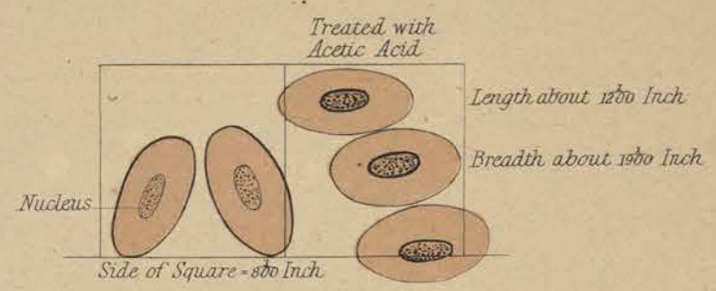

Fig. 5 Urino-genital Organs - Male
(Ventral View)

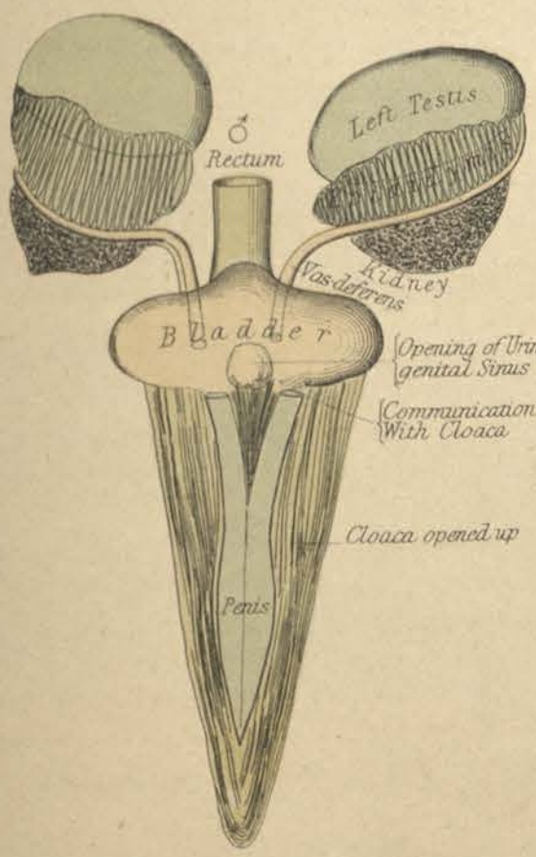

Fig. 4 Larynx & Trachea
(Dorsal View)

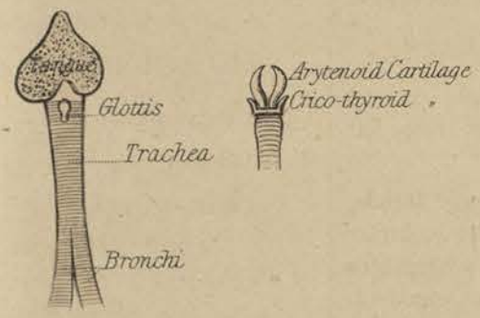

Fig. 7 Openings into Cloaca Female

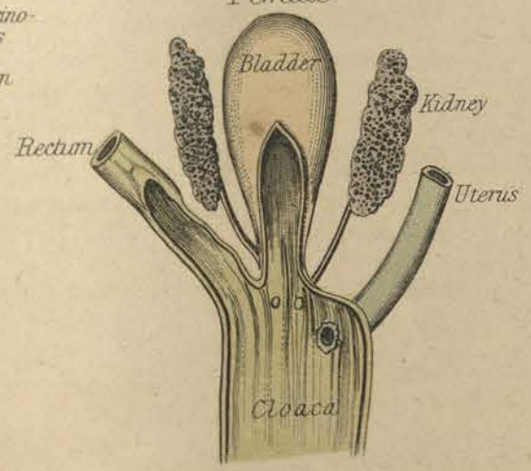

Fig. 6 Genital Organs - Female
(Ventral View)

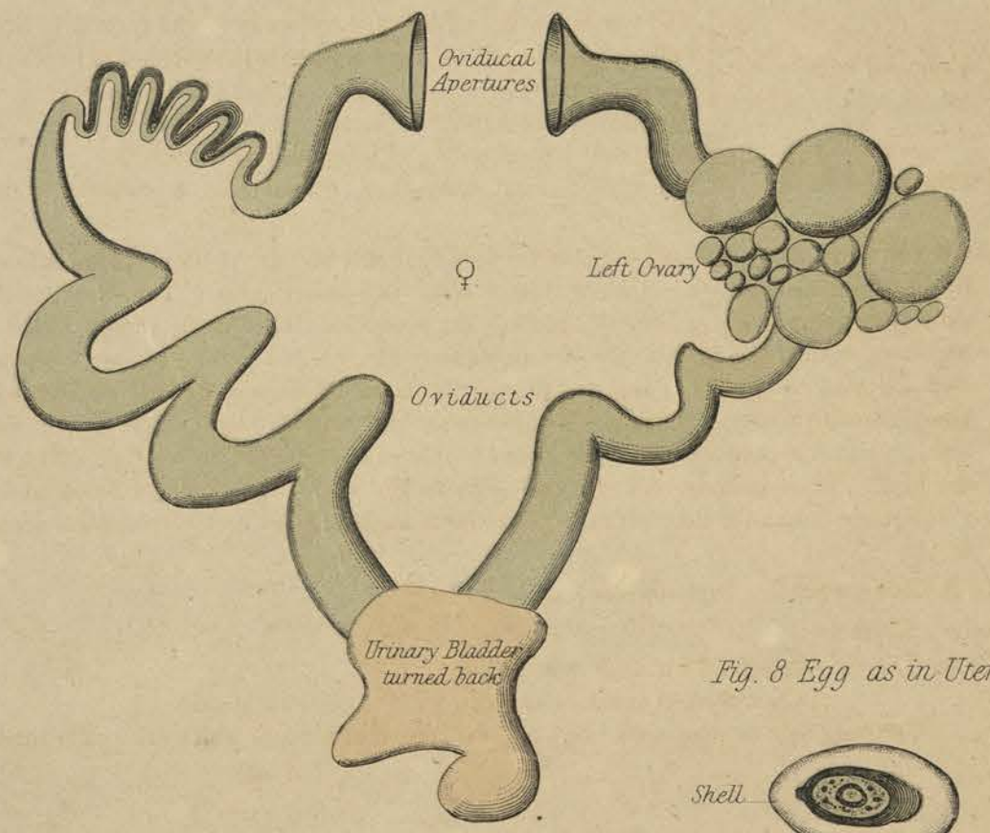

Fig. 8 Egg as in Uterus

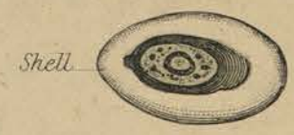

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PLATE XIV.—THE PIGEON.

EXTERNAL AND INTERNAL CHARACTERS.

The Pigeon, like the Rabbit, is well known as a domestic pet, and amid the numerous varieties of domestic breeds the Rock-dove has been chosen, since the others are descended from it. It is found wild on rocky coasts, hence the name.

Birds are well known as feather-clad, warm-blooded, toothless animals, and generally adapted for progression in the air. Pigeons are vegetable feeders, and have a crop in which a large quantity of grain may be stored. There is also a muscular stomach, or gizzard, which with the aid of small pebbles effectually grinds the food into a pulp. Their external configuration and internal organization throw light on their special habits, and their relations to Reptiles and Mammals respectively will be seen in detailed study. The growth of feathers is particularly well seen in this bird.

FIG. 1.

Head, showing:
- Horny beak.
- Cere (L. *cera*, wax), a whitish swelling at base of beak pierced by external nostrils.
- Eye with eyelids and nictitating membrane.
- Auditory aperture below and behind eye, concealed by feathers.

Body with strong and pointed wings.

Tail with strong feathers, or rectrices (L. directors), used for steering.

Leg and foot with coral-red scales.

Foot with four clawed digits, the hallux, or inner toe, turned backwards, and on a level with the rest.

FIG. 2. After removing feathers, which are very easily detached, dissect skin from breast and upper portion of wing to expose breast muscles.

Pectoralis major (L. greater pectoral) originating from keel of sternum, for lowering the wing.

Sub-clavius (*sub*, under; *clavicula*, collar-bone), or second pectoral, beneath pectoral, ending in a tendon, which passes through a pulley in the coracoid to the humerus, for raising the wing.

FIG. 3. Primaries, ten comparatively long feathers arising from manus.

Secondaries, shorter feathers arising from forearm.

Spurious or bastard wing, borne on rudimentary pollex.

FIG. 4. Lay bare trachea in the region of the neck, and through it blow up the air-sacs, then remove sternum carefully to make out their number and position.

Four pair of air-sacs, named from their position in the body.

Inter-clavicular formed by the union of two in the middle line, so that there are nine altogether.

Bronchus giving off branches at right angles to each air-sac, and terminating in abdominal one.

FIGS. 5 and 6. Blow up crop from gullet and expose the various organs without disturbing them.

Skeleton:
- Spinal column divided into four regions.
- Skull pneumatic, being permeated by air-cavities.
- Sternum keeled.

Nervous system:
- Brain completely filling cavity; cerebral hemispheres very large, and cerebellum projecting backward considerably.
- Spinal cord.

Alimentary system:
- Horny bill adapted for pecking.
- Tongue hard.
- Gullet leading into crop.
- Gizzard, or muscular stomach, of pearly lustre.
- Intestine in various folds ending in cloaca.
- Liver large and two-lobed, with a third small lobe.
- Pancreas in loop of duodenum.

Circulatory system:
- Heart with two auricles and two ventricles.
- Aorta turning to right side.

Respiratory system:
- Glottis at entrance to trachea, but no epiglottis.
- Trachea with cartilaginous rings.
- Lungs bright red, fixed to dorsal wall.

Urino-genital system:
- Kidney, three-lobed.
- Testis, reddish brown.

Fig. 1. Columba livia

Fig. 2. Pectoral Muscles for raising & lowering wing

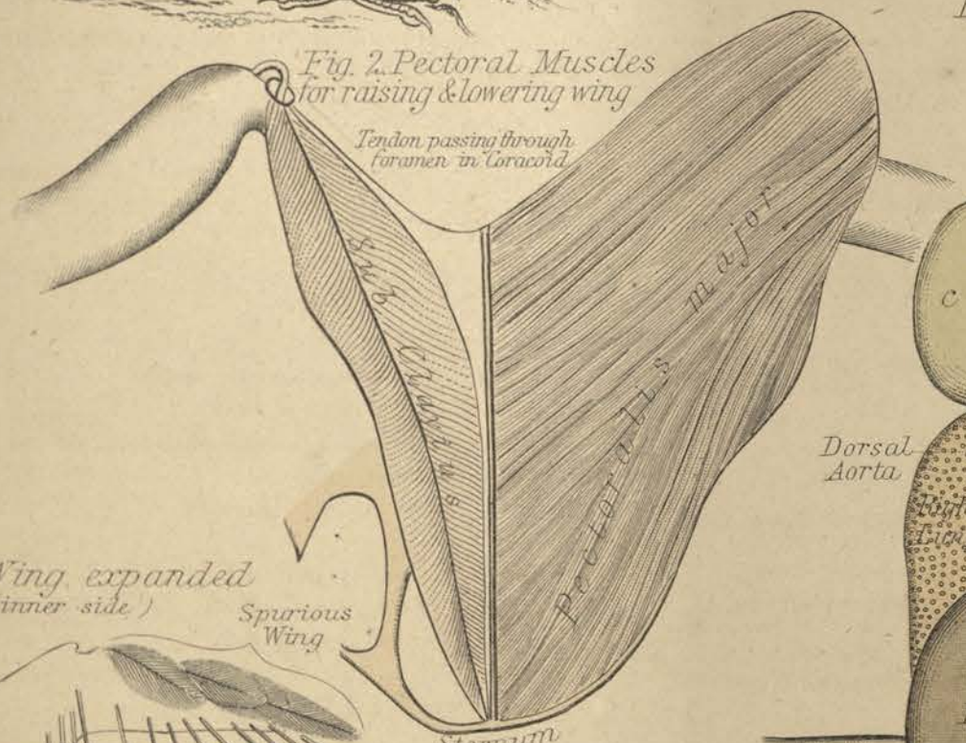

Fig. 3. Wing expanded (inner side)

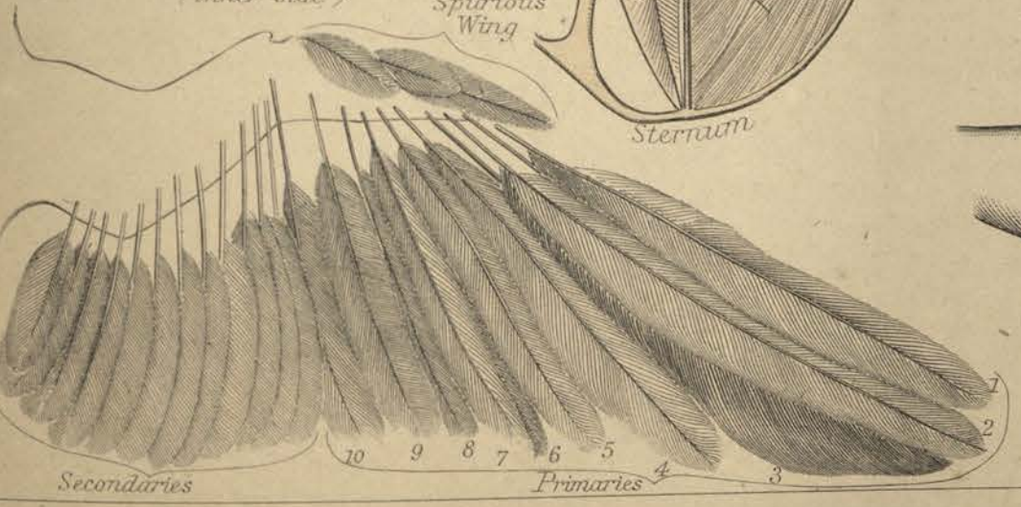

Fig. 4. Relative position of Air-sacs

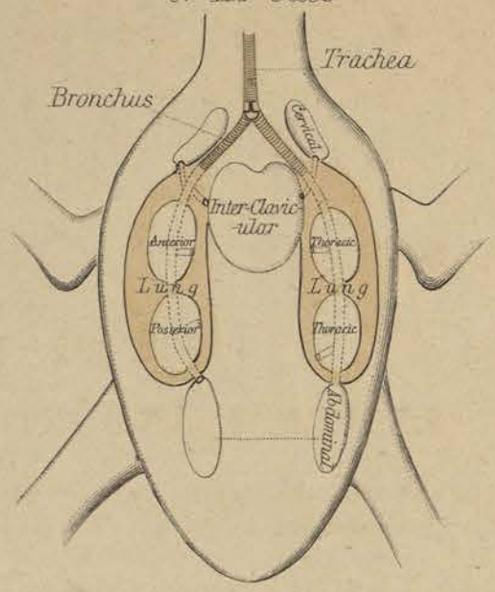

Fig. 5. Dissection from Ventral Surface

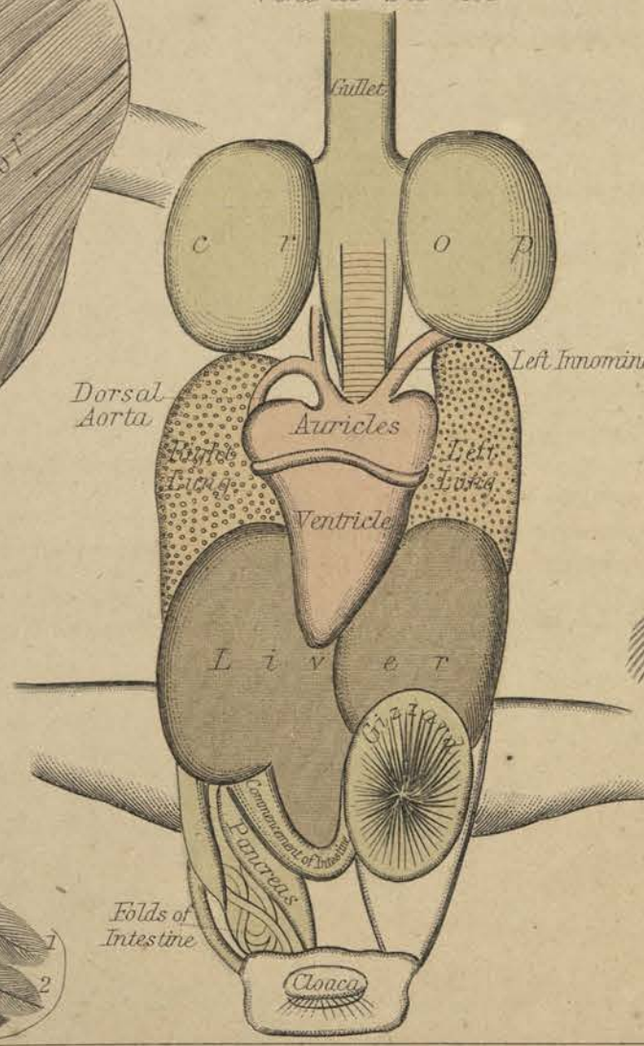

Fig. 6. Dissection from Right side

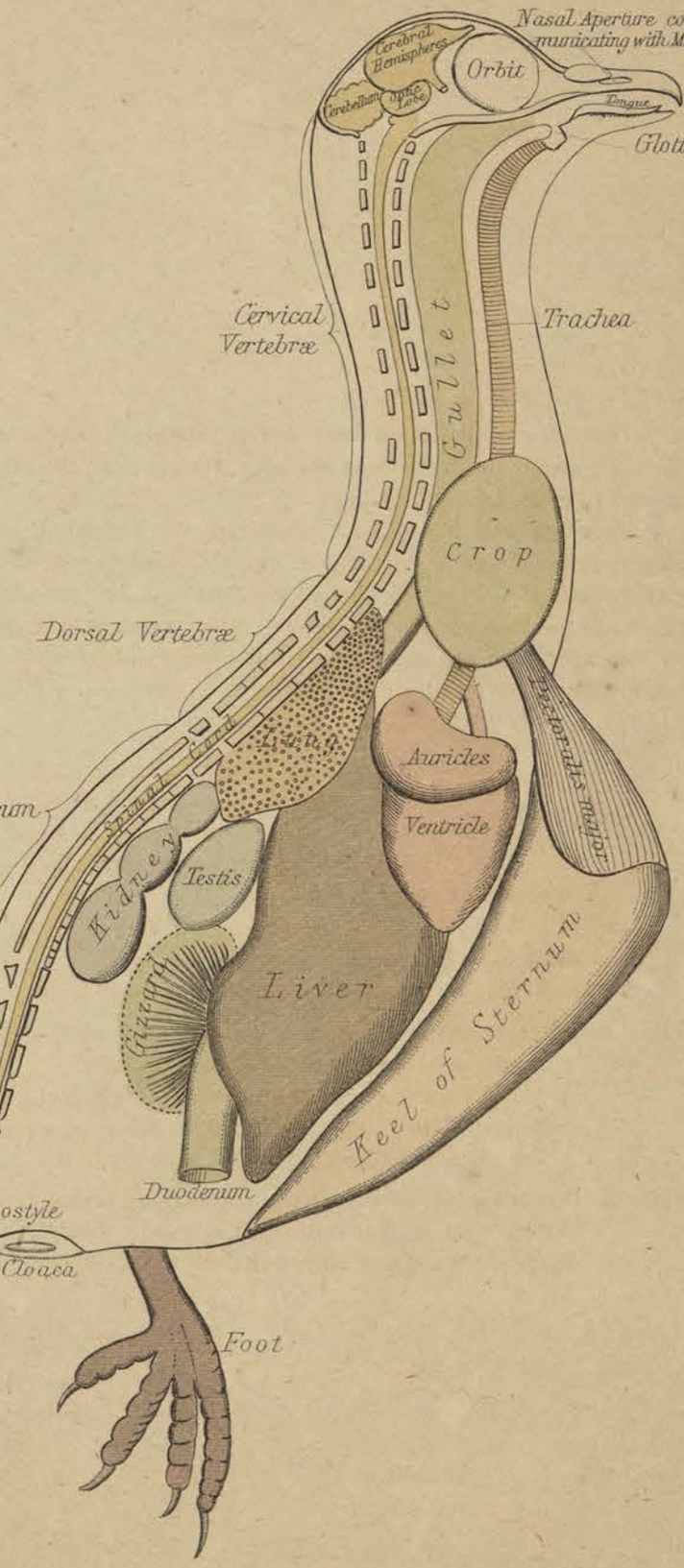

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PLATE XV.—THE PIGEON—*continued.*

SKELETON.

ENDOSKELETON—

FIG. 1. Calamus (L. a quill), or barrel.
Inferior umbilicus, a hole at the base into which the vascular papilla penetrates.
Superior umbilicus, a hole on the under surface where rachis begins.
Rachis (Gr. a shaft), square and solid.
Vexillum (L. a vane), composed of rachis bearing barbs.

EXOSKELETON—

Preparation of Skeleton.—The skeleton may be prepared by boiling after plucking, and since a number of the bones have the marrow replaced by air, there is but slight discolouration. The process of boiling brings out clearly what parts of the skeleton are *pneumatic*, since these parts are conspicuously white; and it is possible to determine that the skull and sternum, the coracoids and humerus, the pelvis, and most of the vertebræ are pneumatic.

FIG. 2. Atlas, keyhole-shaped.
Axis, with odontoid process fitting into lower aperture of atlas.
Third cervical—
Cervical rib is an outstanding process on side of centrum, completely fused with it, and enclosing vertebrarterial canal.
Zygapophysis (Gr. *zugos*, a yoke; *apophusis*, a process), an articular surface corresponding to a similar surface on preceding or succeeding vertebra.
Hypapophysis (Gr. *hupo*, under), a median process on under surface.
Fourth cervical, showing the characteristic structure of the centra of cervical vertebræ—anterior face concave from side to side, convex from above downwards, and the reverse on posterior face.

FIG. 3. First dorsal—Rib with capitulum (L. little head) attached to centrum, and tuberculum (L. little swelling) attached to transverse process.
Second dorsal—Rib with uncinate process (L. *uncus*, a hook).
Seventh dorsal (fig. 4)—Fused with centrum, and, like the first, without uncinate process.

FIG. 4. Sacrum united by suture with pelvis, consisting of thirteen fused vertebræ as indicated by the tranverse processes.

FIG. 5. Third caudal—Centrum convex anteriorly and slightly concave posteriorly.
Pygostyle (Gr. *puge*, the rump), the ploughshare-shaped bone supporting the great feathers of the tail.

FIG. 6. Sternum—Keel very prominent.
Membranous fontanelles, unossified portions.
Pectoral arch—Scapula projecting backwards over the ribs.
Coracoid uniting with scapula to form glenoid cavity for humerus, and fitting into groove on sternum.
Clavicles united, known as furculum (L. *furca*, a fork), from the shape, or merrythought; strong in birds of powerful flight, but weak, for instance, in domestic fowl.

FIG. 7. Fore-limb—
Humerus stout and pneumatic, with triangular process for insertion of pectoral muscle.
Radius and ulna, the latter thickest.

Manus . . . . . {
- Carpus { Proximal division, two bones. / Distal division fused with metacarpals.
- Metacarpus—Three metacarpals fused, corresponding to three digits.
- Digits—I. (Pollex), one joint.
  II. Two joints, the first expanded ventrally into a thin plate.
  III. One joint.

FIG. 8 and FIG. 4. Pelvic arch—
Ilium extending whole length of sacrum, and overlapping last dorsal rib anteriorly.
Ischium fused with ilium and forming sciatic (contraction for sacro-ischiatic) foramen.
Pubis, a slender rod-like bone widely separated from its fellow, with obturator foramen at anterior end.
Acetabulum, the hollow meeting-place of the three bones, centre of fibrous tissue, hence a hole in the dry state.

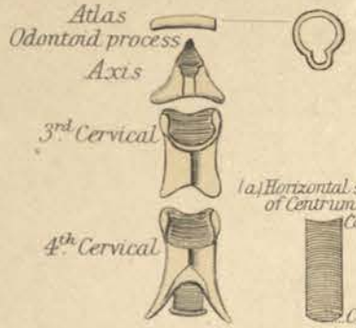
FIG. 9. Hind-limb—
Femur with rounded articular head.
Tibia and fibula. Fibula, a mere strip of bone. Tibia with astragalus fused to it, hence it is called tibio-tarsus. (In the young fowl, at the age when it is brought to table, the astragalus can be detached from the tibia.)

Pes (ankle-joint is between the two divisions of the tarsus) . . . . . {
- Tarso-metatarsus, consisting of three metatarsals fused with the distal division of tarsus.
- First metatarsal separate.
- Digits—I. (Hallux) inner toe turned backwards, two joints.
  II. Three joints.
  III. Four joints.
  IV. Five joints.

Fig. 1. Wing Feather

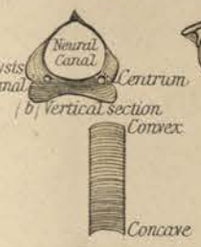
Fig. 2 Cervical Vertebræ (12)

Dorsal View.



(a) Horizontal section of Centrum

(a) Anterior View of 3rd Cervical

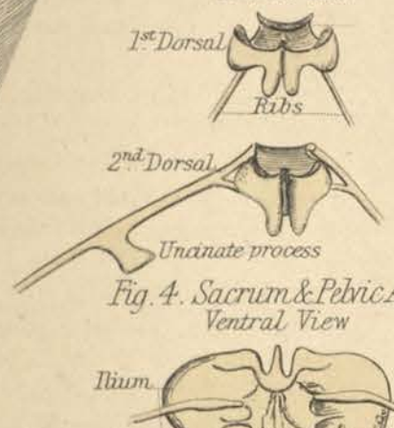


(b) Posterior View

(b) Vertical section

Fig. 3. Dorsal Vertebræ (7)

Dorsal View.



Side View

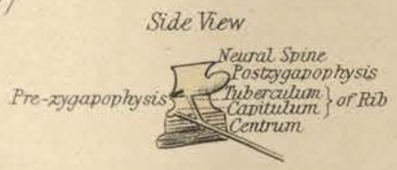


Fig. 4. Sacrum & Pelvic Arch

Ventral View

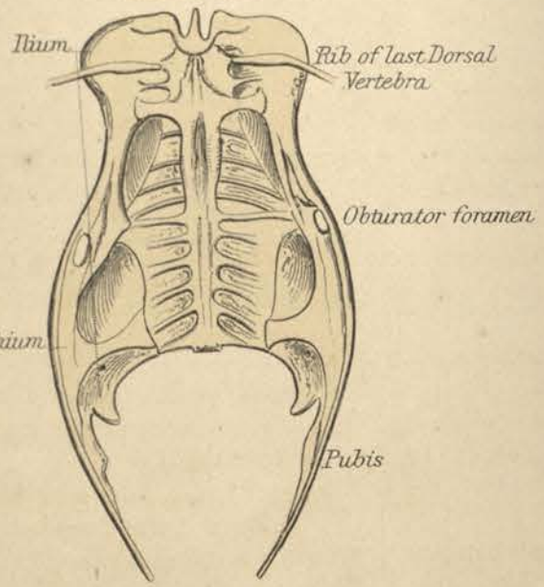
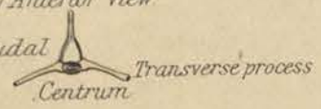
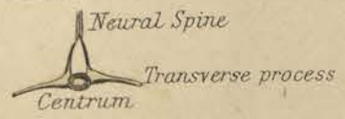


Fig. 5. Caudal Vertebræ

(a) Anterior View



(b) Posterior View



Plough share bone (side view)

Fig. 6. Pectoral Arch

(Ventral View)

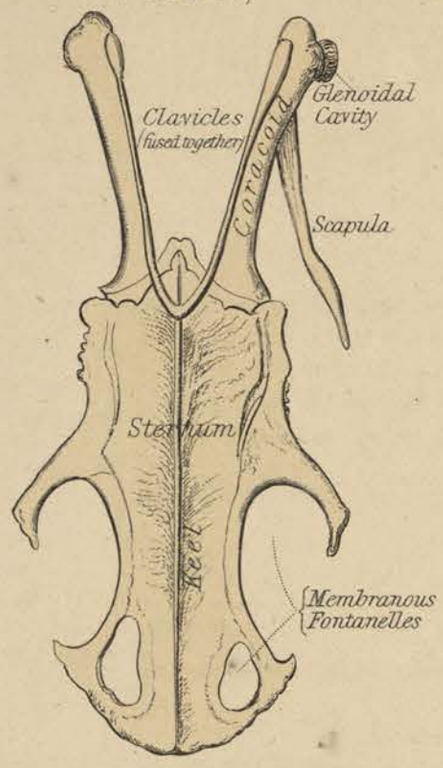


Fig. 8 Pelvic Arch

Fig. 7 Right Fore Limb expanded

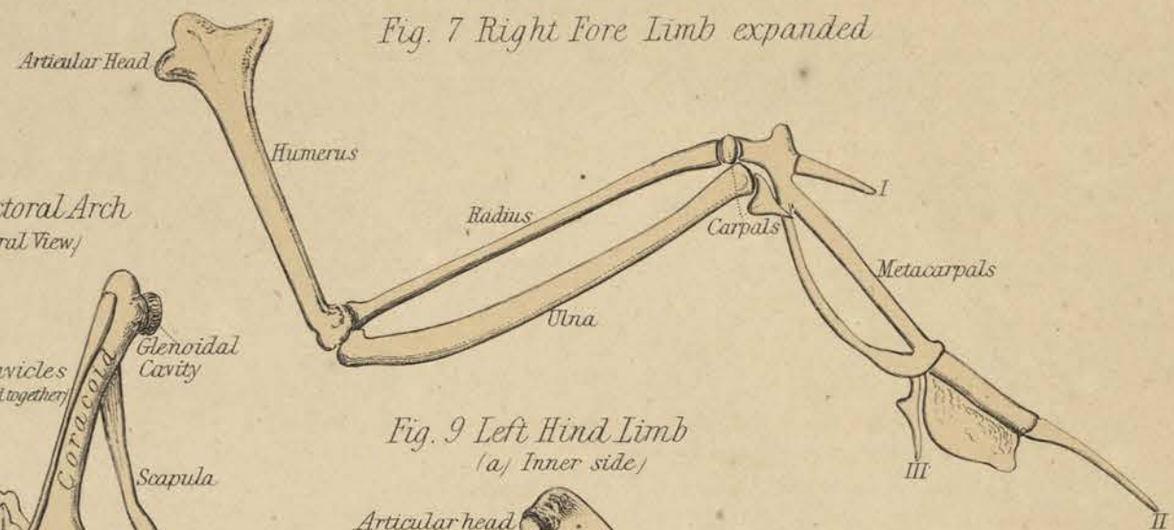
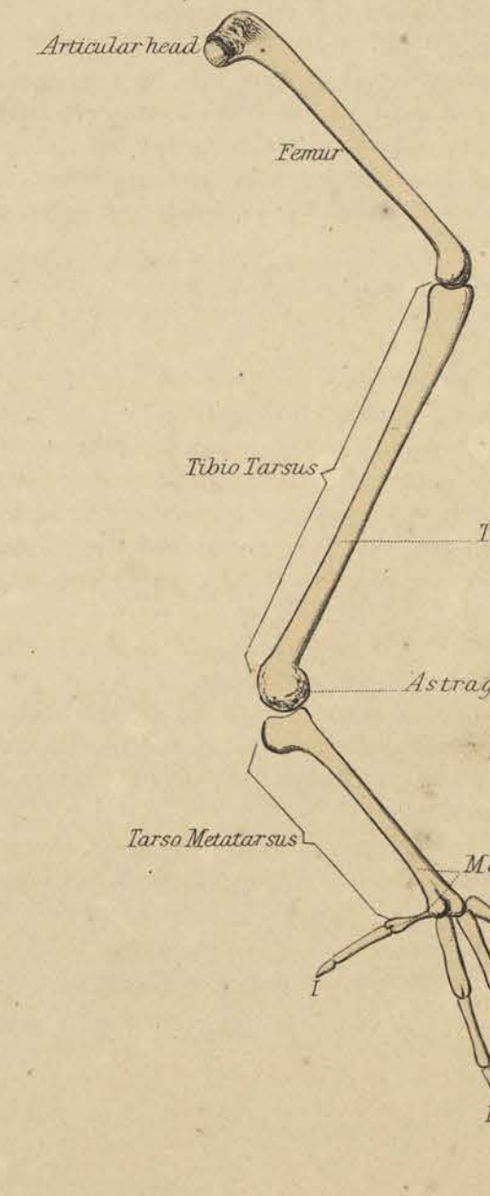


Fig. 9 Left Hind Limb

(a) Inner side)



(b) Front view of portion

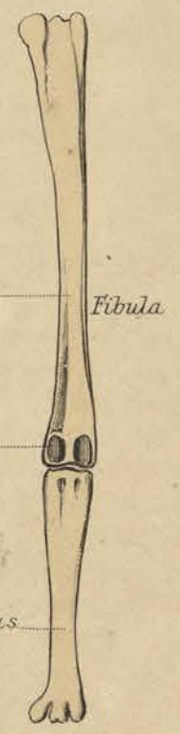


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PLATE XVI.—THE PIGEON—*continued.*

SKELETON, NERVOUS AND SENSE ORGANS, ALIMENTARY SYSTEM.

SKELETON—*concluded.*

FIG. 1. Dissect out skeleton of tongue, passing backwards to parts connected therewith—
- Hyoid arch, consisting of cerato-hyals united to form a tongue-piece.
- Branchial arches, consisting of—
  - First basi-branchial.
  - Second basi-branchial articulating with first.
  - Cerato-branchial articulating with basi-branchials.
  - Epi-branchial, the posterior end of branchial arch.

FIG. 2. The skull in adult is one bony mass, the different bones only being separable in the fœtal state. In a very young chicken most of the bones may be separated by maceration, or they may be seen in the skull of an ostrich, where the sutures persist for a long time.

Dorsal view—
- Supra-occipital forming upper boundary of foramen magnum.
- Parietals forming posterior arch of head.
- Frontals forming roof.
- Nasals at base of beak.
- Pre-maxillæ encased in horny sheath.

Ventral view, lower jaw removed—
- Supra-occipital.
- Basi-occipital, with occipital condyle notched.
- Basi-sphenoid, including basi-temporal plate outside and projecting rostrum in front.
- Quadrate, with outer and upper process fitting on to squamosal, lower to pro-otic, inner directed towards orbit, and anterior, double-headed, articulating with quadrato-jugal on outer side and pterygoid on inner side.
- Palatine, the slender forward continuation of pterygoid.
- Maxilla, united by jugal to quadrato-jugal, and to palatine by maxillo-palatine process.

Side view, including mandible—
- Mesethmoid, forming anterior part of inter-orbital septum, with groove at top for passage of olfactory nerve.
- Lachrymal, forming anterior wall of orbit.
- Squamosal, forming lateral wall of cranium posterior to orbit.

Ramus of mandible . {
- Articular, with depression into which quadrate fits.
- Angular truncated posteriorly.
- Sur-angular (L. contraction for *supra*, above).
- Dentary united in front with its fellow.

DIAGRAM 1. Bones separated and grouped together (cartilage-bones represented of a lighter shade than membrane-bones)—

Occipital segment . {
- Basi-occipital, with single occipital condyle.
- Ex-occipitals, to which the ear-capsules are usually ankylosed.
- Supra-occipital.

Parietal segment . . {
- Basi-sphenoid, with rostrum in front representing portion of para-sphenoid.
- Ali-sphenoids large.
- Parietals.

Frontal segment . . {
- Pre-sphenoid, the posterior ossified portion of inter-orbital septum.
- Orbito-sphenoids, not usually represented as distinct ossifications.
- Frontals very large and roofing orbits.

Vomer (absent in Pigeon).

Pre-maxillæ united into a tri-radiate bone.

Maxilla, jugal, and quadrato-jugal united into a slender rod, forming an angle of about 50° with quadrate.

Region of nose . . {
- Nasals.
- Mesethmoid.

Region of eye . . . Lachrymal.

Region of ear . . . Squamosal (others not indicated).

Palato-quadrate arch {
- Quadrate, giving articulation to mandible.
- Pterygoid, stretching from quadrate to palatine.
- Palatine, extending to pre-maxilla.

Mandible, consisting of five pieces on each side—Articular, angular, sur-angular, splenial (L. *splenium*, a splint), and dentary.

NERVOUS SYSTEM AND SENSE-ORGANS—

FIG. 3. As the brain completely fills the cavity of the skull, carefully remove bit by bit the thin pneumatic bone till the whole brain is exposed—
- Olfactory lobes arising from anterior end of cerebral hemispheres.
- Cerebral hemispheres hollow.
- Optic thalami with pineal gland on roof.
- Optic lobes lateral and towards the base, as if pushed aside by the enlargement and meeting of the cerebral hemispheres and cerebellum.
- Cerebellum with transverse markings. Median lobe or vermis (L. a worm), lateral lobes or flocculi (L. locks of wool).
- Medulla oblongata.

FIG. 4. Spinal cord enlarging at the origin of the plexus (L. plaited) of spinal nerves for supplying wing and hind-limb.
- Sinus rhomboidalis is an enlargement of the central canal of spinal cord.
- Sympathetic, consisting of two longitudinal gangliated cords.

FIG. 5. Muscles connected with nictitating membrane—
- Pyramidalis muscle arising from inner surface of eyeball, and ending in a tendon which winds round optic nerve to become attached to nictitating membrane.
- Bursalis muscle arising from top of sclerotic.
- The contraction of the pyramidalis draws the nictitating membrane over the eye, while the contraction of the bursalis prevents the tendon from slipping over optic nerve.

FIG. 6. Pecten (L. a comb) is a plaited fan-like membrane extending from the entrance of optic nerve to the vitreous humour.

ALIMENTARY SYSTEM—

FIG. 7. Showing liver and pancreas, and the relation of their ducts to the alimentary canal—
- Liver without gall-bladder, with two bile-ducts opening into duodenum.
- Pancreas elongated and longitudinally fissured, with three pancreatic ducts opening into duodenum—one in advance of bile-duct.

FIG. 7 and DIAGRAM 2.
- Gullet dilating into crop.
- Ingluvies (L. the crop), consisting of two lateral compartments, and serving as a storehouse for grain.
- Proventriculus (L. *pro*, before; *ventriculus*, stomach), or glandular stomach, which secretes the gastric juice.
- Gizzard, or muscular stomach, thick-walled, but thin-walled in birds of prey.

Small intestine . . . . {
- Duodenum.
- Jejunum.
- Ileum.

Large intestine having two small cœca at commencement.

Digestion of Food.—The peas or grain pass into the crop, where they undergo maceration; then into the proventriculus to be mixed with the gastric juice; next entering the gizzard, to be ground between the thick muscular walls radiating from the central tendon, aided by the small stones introduced with the food. The pulpy food is now thoroughly mixed with the gastric juice and ready to be absorbed by the intestine.

Fig 1. Hyobranchial (Dorsal View)

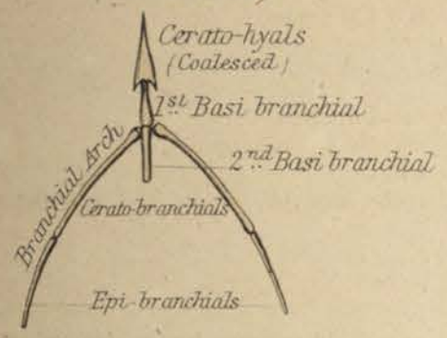

Fig 2. Skull

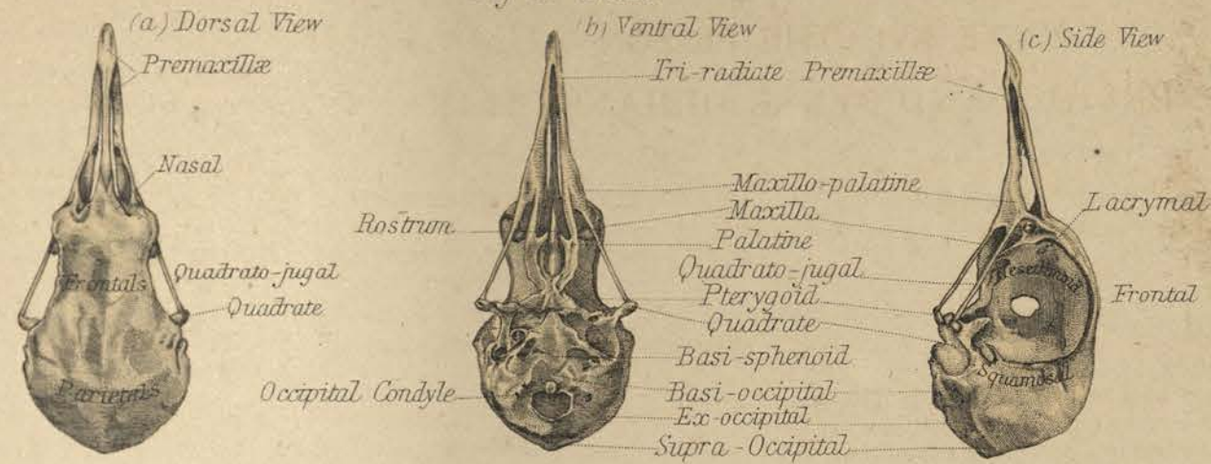

Fig 3. Brain

Diagram 1 Disarticulated Skull of Bird

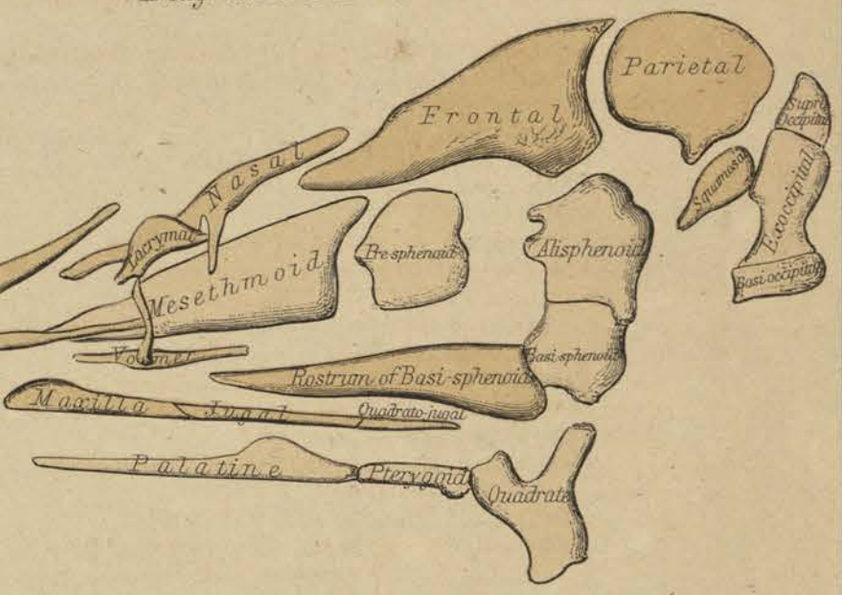

Fig 4. Spinal & Sympathetic Nervous System (Ventral View)

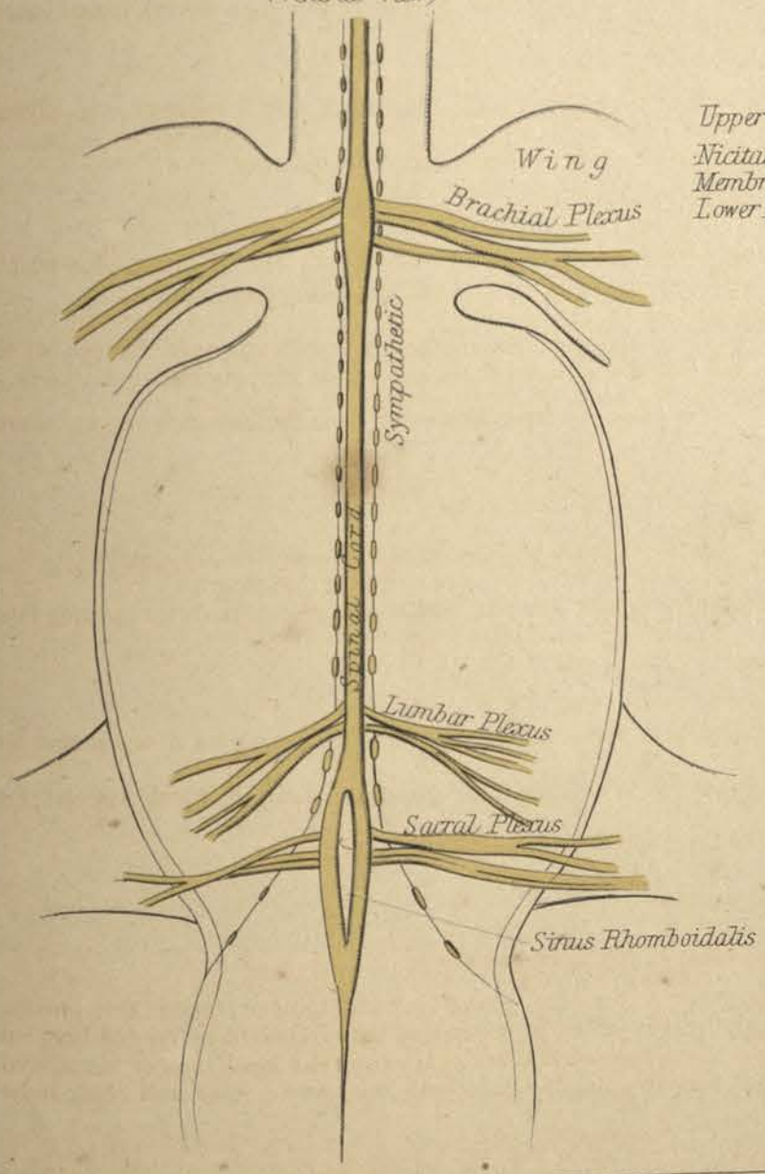

Fig 5. Eye

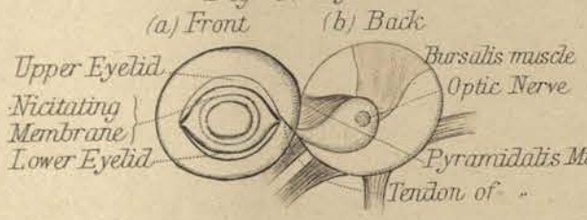

Fig 6 Position of Pecten

Mandible

Fig 7. Alimentary Canal & Appendages

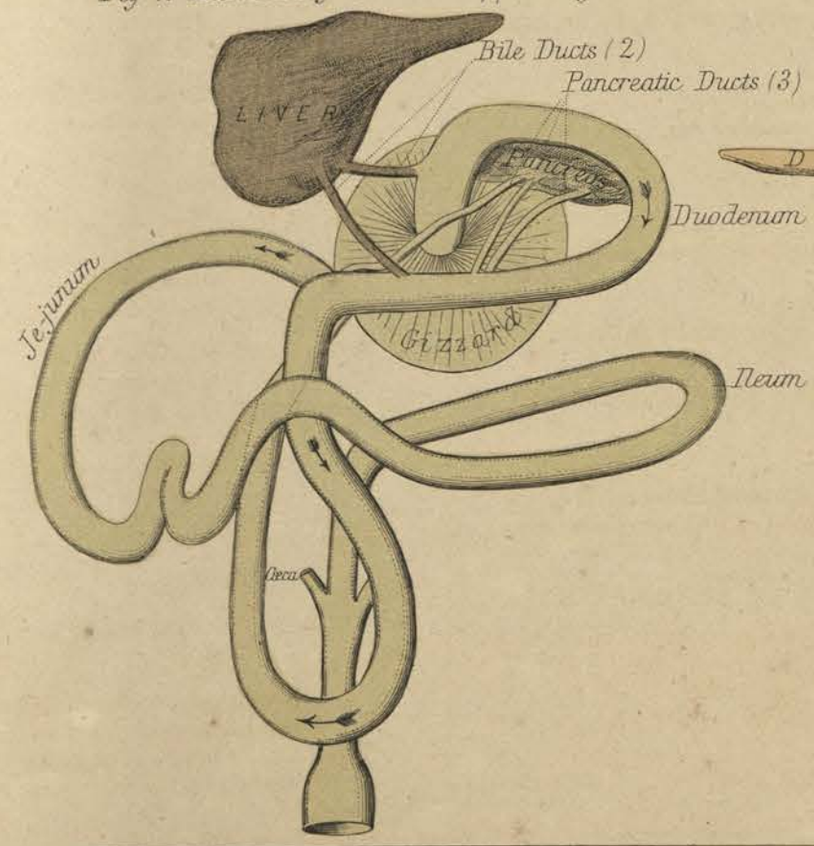

Diagram 2 Alimentary Canal

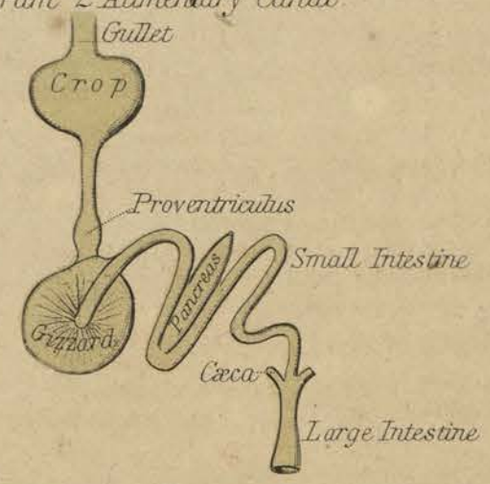

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PLATE XVII.—THE PIGEON—*concluded.*

CIRCULATORY, RESPIRATORY, AND URINO-GENITAL ORGANS.

CIRCULATORY SYSTEM—

FIGS. 1 and 2. After removal of sternum, the heart can be displayed with its vessels.

Heart . . . . { Right and left auricles, separated externally from the ventricles and from each other by a ridge of fat.
Right and left ventricles, without any distinct external division.

Principal arteries { Carotid, ascending towards head.
Sub-clavian, passing outwards and dividing into brachial, thoracic, and internal mammary.
Aorta, bending over to the right and then descending.
Pulmonary, dividing into two branches, one for each lung.

Principal veins { Superior vena cava, right and left, formed by jugular, brachial, and thoracic.
Pulmonary returning from lung.
Inferior vena cava, passing along side of dorsal aorta towards heart.

FIGS. 3 and 4. Right auricle, the largest, receiving superior and inferior venæ cavæ.
Left auricle, receiving pulmonary veins.
Right ventricle, relatively thin walled, giving off pulmonary artery with venous blood.
Left ventricle, relatively thick walled, giving off right aorta.
Chordæ tendineæ (L. tendinous cords), cords to keep flaps of left auriculo-ventricular valve in place.
Muscular fold forming right auriculo-ventricular valve.

FIG. 5 (also 1 and 2).

Arteries—

Right innominate artery . { Common carotid to head.
Sub-clavian, dividing into . { Internal mammary, to inner surface of sternum, etc.
Thoracic, to pectoral muscles.
Brachial, to forelimb.
Aorta arching over to right side.
Remains of left aortic arch shown, round which recurrent laryngeal nerve turns.

Left innominate artery . { Common carotid.
Sub-clavian, dividing into . { Internal mammary.
Thoracic.
Brachial.

Dorsal aorta . { Visceral arteries not shown.
Femoral.
Sciatic.
Hypogastric.
Sacra media.

Pulmonary artery dividing for each lung.

Veins—

Superior vena cava formed by { Jugular from head
Sub-clavian formed by { Brachial.
Thoracic.

Inferior vena cava formed by two common iliac veins, which receive . { Cocoygeal from tail.
Hypogastric from each side of pelvis.
Sciatic and femoral from hind-limb.
Renal from kidneys.

Portal vein, having its root in vein arising from coccygeal portion of common iliac veins, and called coccygeo-mesenteric because it goes to mesenteric vein.

Pulmonary veins opening by a single trunk into left auricle.

FIG. 6. Coloured corpuscles, oval, nucleated, and large relatively.

RESPIRATORY SYSTEM—

FIG. 7. Glottis, behind tongue in floor of pharynx, and leading through larynx into trachea, which is strengthened by cartilaginous rings, and dividing into two bronchi.
Aorta, crossing right bronchus.
Lungs, bright red and spongy in texture.

FIG. 8. Each lung is fastened so closely to the dorsal wall of the thorax that it fits into the interspaces between the ribs, and on its ventral surface the layer of peritoneum is continued to form the pleura upon which muscular fibres are distributed, arising from the ribs and vertebral column, thus representing a diaphragm.
Inspiration is effected by thoracic suction. By the action of intercostal muscles the angle between the vertebral and sternal ribs becomes more open, and as the sternal ribs straighten the sternum is depressed, and the cavity of the thorax and abdomen enlarged.
The lung is only slightly distensible, but the air-sacs in which the bronchi end exceedingly so, and the result is, when the sternum is depressed that the air rushes along the main bronchial tubes and fills the air-sacs. Then when the air-sacs are pressed, *expiration* is effected, and the air is swept out by the bronchial tubes and trachea.
Respiration is different, too, in standing and flying. When flying the weight of the body is supported by the shoulder-girdle, with which the wings are connected and also the sternum, so that the relatively fixed part is the sternum. Hence it follows that in flying the movable lid of the air-cavity is the upper, while in standing it is the lower, or sternum, as described above.

FIG. 9. Larynx, sometimes called superior to distinguish it from the syrinx or inferior larynx—
Thyroid cartilage, a large single piece.
Cricoid cartilages (Gr. *krikos*, a ring), consisting of three pieces.
Arytenoid cartilages, consisting of two pieces and articulated with cricoids.

FIG. 10. Syrinx (Gr. *surinx*, a pipe), or organ of voice, at bifurcation of trachea.
It consists of a drum-like chamber in which elastic membranes can be set vibrating, so as to give rise to the cooing sound. The pitch and intensity or strength of that coo is regulated by two sets of muscles—(1) Intrinsic muscles, connected entirely with the trachea. Their effect is to stretch the membranes. (2) Extrinsic muscles, attached to sternum as well, and called *sterno-tracheal*. Their effect is to shorten the tracheal tube and relax the tension of the membranes.

URINO-GENITAL SYSTEM—

FIG. 11. Kidney, in three lobes corresponding to depressions in pelvic bones.
Ureter, leading almost straight to cloaca.
Testis, attached to dorsal wall of abdominal cavity by peritoneum.
Vas deferens, wavy and dilating before entering cloaca.

FIG. 12. Rectum, opening on dorsal wall of cloaca.
Ureter.
Vas deferens, opening on the top of a minute papilla.
Bursa fabricii (L. *bursa*, a pouch), a glandular body opening beneath ureters.

FIG. 13. Left ovary and oviduct alone developed.
Graafian follicles, or ovi-sacs containing the primitive ova surrounded by yolk, derived from modifications of the cells lining the ovi-sacs.
Oviduct, much convoluted, with funnel-shaped oviducal aperture, and dilating into a uterus before opening into cloaca.

FIG. 14. A hen's egg is larger, and may be taken to show the internal structure.
Cicatricula (L. a little scar), a whitish spot on that side of the yolk which naturally floats uppermost. It is the foundation of the embryo.
Vitellus (L. yolk), for nutrition of the embryo, invested by vitelline membrane.
Successive deposits formed as egg descends oviduct { Albumen (L. *albus*, white), or white of egg.
Shell-membrane lining shell, of fibrous structure.
Shell, calcareous and porous.

CLASSIFICATION—

Sub-Kingdom—Vertebrata.
Class—Aves (L. Birds)—
External covering of feathers.
Heart four-chambered.
Blood hot.
Natural Order—Columbæ (L. Pigeons), or Gyrantes (L. *gyrans*, whirling round), distinguished from their more immediate allies by being birds of powerful flight and aerial in habit.
Family—Columbidæ (including Doves and Pigeons and the extinct Dodo).
Genus—Columba.
Species—C. livia (L. *liveo*, to be leaden coloured), or Blue Rock-Dove.

Fig. 1 Heart & Great Vessels
(Ventral View)

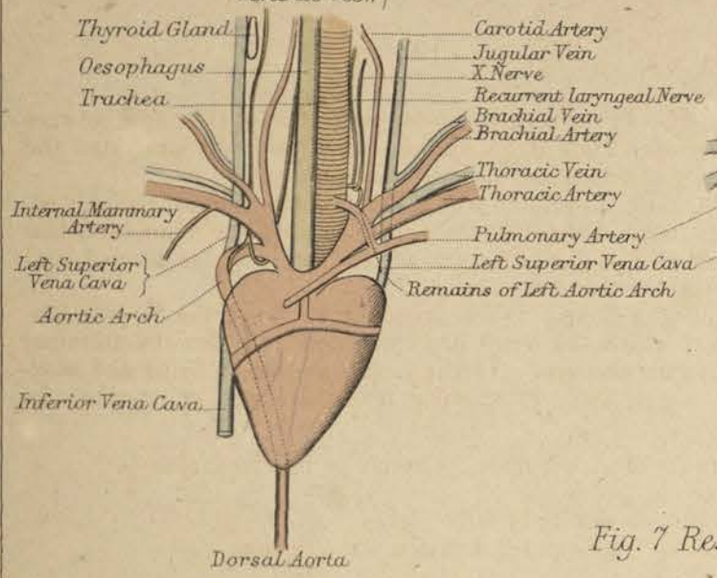

Fig. 2 Heart
(Dorsal View)

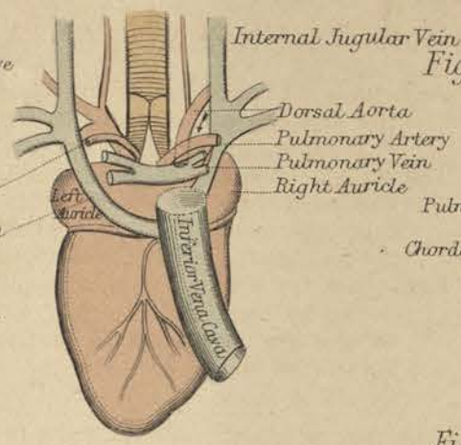

Fig. 3 Cavities & Openings of Heart
(Dorsal View)

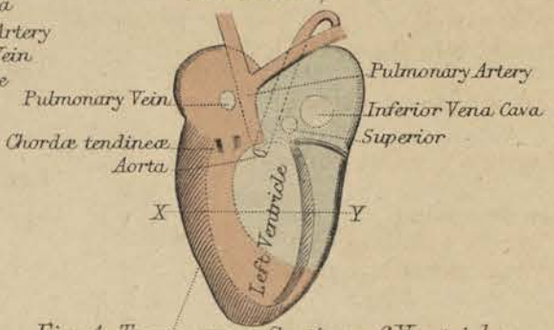

Fig. 4 Transverse Section of Ventricles
through line X.Y.

Fig. 5 General Course of Circulation

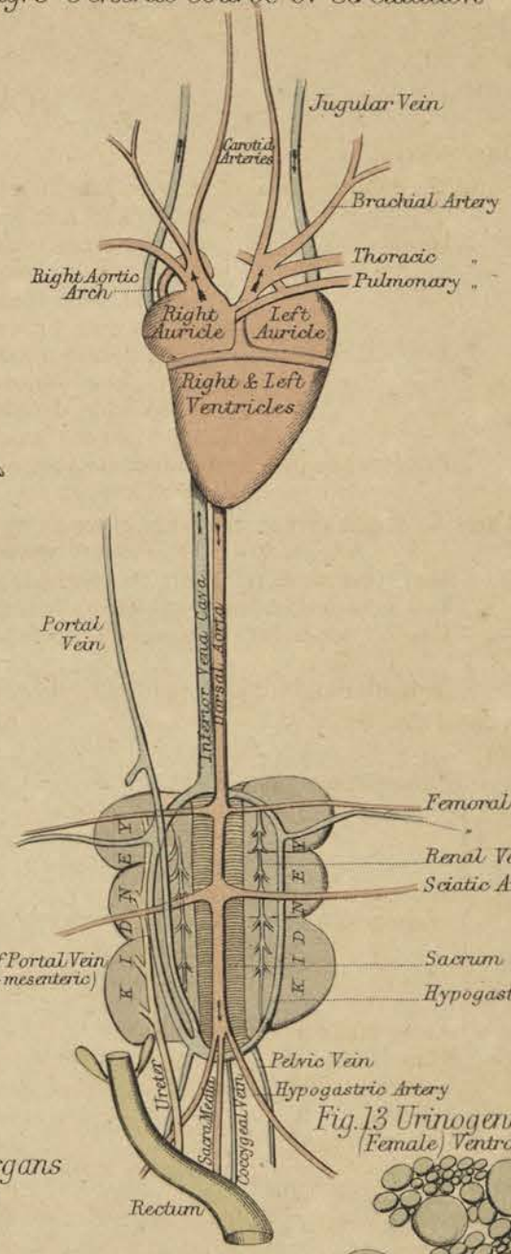

Fig. 6 Red Blood Corpuscles
Treated with Magenta

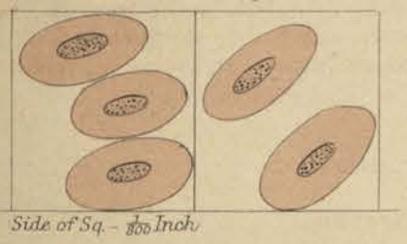

Fig. 7 Respiratory Organs

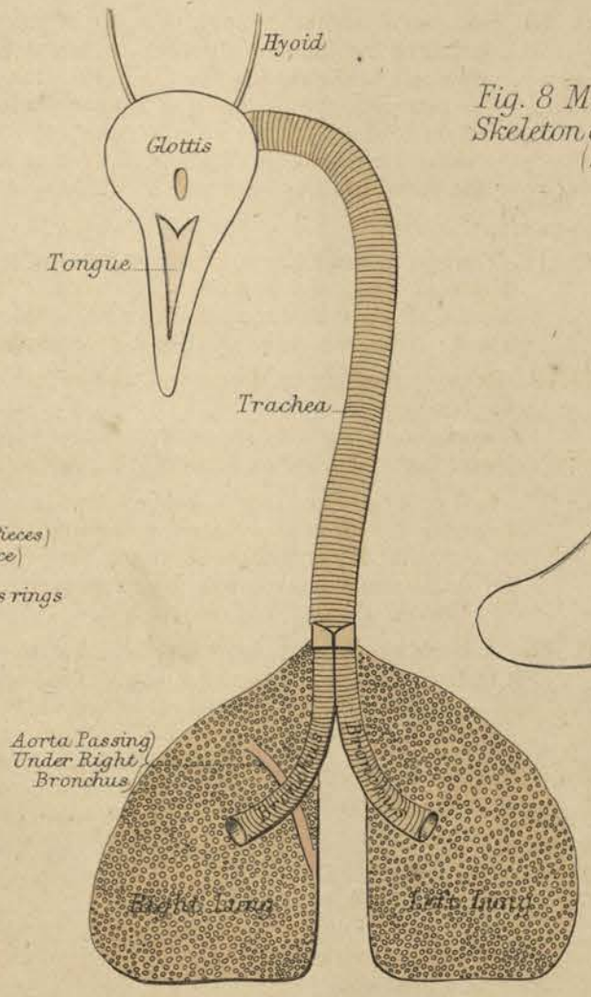

Fig. 8 Mechanism of Respiration
Skeleton of Thorax & Shoulder Girdle
(Semi-diagrammatic)

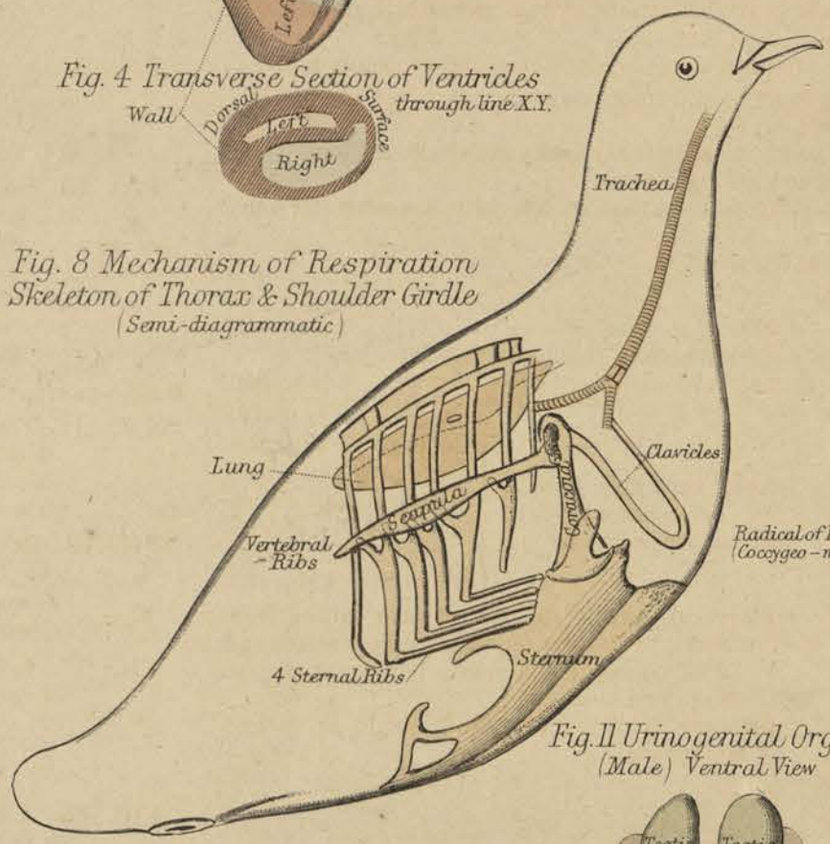

Fig. 9 Larynx
(Side View)

Fig. 10 Syrinx

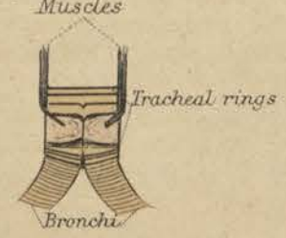

Fig. 11 Urinogenital Organs
(Male) Ventral View

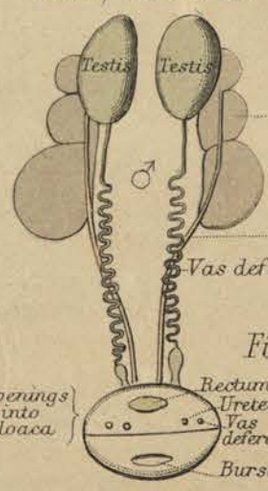

Fig. 12 Openings into Cloaca
(Side View)

Fig. 13 Urinogenital Organs
(Female) Ventral View

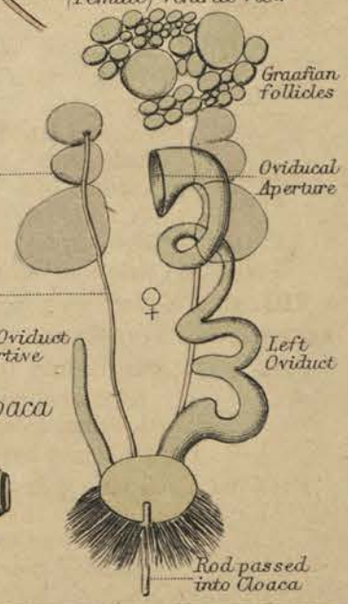

Fig. 14 Pigeon's Egg

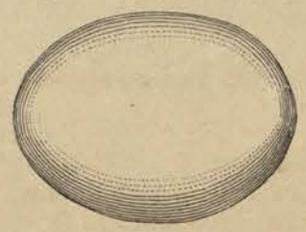

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PLATE XVIII.—THE RABBIT:

EXTERNAL CHARACTERS AND INTERNAL ORGANS.

The Rabbit is a convenient representative of the Mammal, being of good size and readily obtainable. Its habits are more or less familiar to all, and the student will notice many points in its organization correlated with these habits. Thus the abdomen is large relatively to the size of the thorax or cavity of the chest, and this is the rule in herbivorous mammals, because a large intestine is required to get the bulk of the nutriment out of vegetable food. The front teeth are chisel-shaped for nibbling, and the lower jaw is articulated to the skull in such a way that it allows of a backward and forward motion for the same purpose. Its claws are evidently of use in making its burrow, and the third transparent eyelid protects the eye from injury by the dry earth tossed about. The Rabbit thus affords useful lessons while alive, and is a good subject for dissection when dead.

FIG. 1.

GENERAL EXTERNAL CHARACTERS—

Integument hairy, passing inside mouth and over ground surfaces of feet.

Head . . . . . { External ears large. / Eyes with eyelids and nictitating membrane. / Vibrissæ (L. *vibro*, I quiver), or whiskers, on upper lip. / Anterior nares. / Mouth.

Mammary glands with their teats (in female) situated on thorax and abdomen.

Tail short and curved up.

Fore-limb ending in five clawed digits.

Hind-limb ending in four clawed digits.

INTERNAL PARTS—Alimentary system in detail.

Skeleton . . . . { Spinal column—dorsal vertebræ showing cut ends of vertebral ribs. / Sternum giving off sternal ribs.

Nervous system . . Seventh or facial nerve branching to muscles of the face.

Muscular system . . Panniculus carnosus, a thin muscle attached to skin.

Alimentary system . { Gullet slender, the food which passes along it being finely divided by the gnawing teeth. / Stomach, with its cardiac or left end, and its pyloric or right end. / Intestine { Duodenum forming a loop. / Ileum, reddish, dilating into sacculus rotundus (L. round bag), where it enters cæcum. / Cæcum (L. blind), ending blindly in the appendix vermiformis (L. worm-like appendage). / Colon with sacculated walls, a direct continuation of cæcum. / Rectum ending in anus. / Liver composed of five lobes—two on right side, three on left. / Gall-bladder in right central lobe with duct. / Pancreas in loop of duodenum with pancreatic duct, breaking up into tubules and ending in lobules composing pancreas. Pancreatic duct enters intestine some distance in advance of bile-duct. / Spleen near and posterior to broad end of stomach.

Diaphragm between thorax and abdomen.

Circulatory system . { Heart, showing two auricles and two ventricles. / Aorta arising from left side of heart. / Inferior vena cava passing beneath spinal column like aorta.

Respiratory system . Lungs—right divided into three lobes, left into two.

Urino-genital system { Kidneys—right most anterior, with adrenal on inner face. / Ureters passing from inner side, entering bladder. / Ovary, an oval dotted body. / Oviduct—Fallopian tube nearest ovary, passing into uterus.

FIG. 2.

Secreting corpuscles, each containing a nucleus.

FIG. 3.

Lobule or subdivision of parotid gland with the salivary ducts dividing and subdividing.

FIGS. 4 and 5. Portions of duodenum (not ileum)—

Mucous membrane, showing the following structures . . { Villi (L. *villus*, the nap in cloth), small projections. / Lieberkuhnian glands, depressions. / Brunner's glands, depressions ending in convoluted tubes in sub-mucous tissue. / Valvulæ conniventes (L. winking valves), transverse folds of mucous membrane.

Fig. 1 Dissection from left side - Alimentary canal laid out.
Female

External Ear
VII Facial nerve
Vibrissæ
Mouth
Anterior Nares
Sternum
Pectoralis major
5 Digits
Fore Limb
Aorta
Anterior Vena Cava
Left Adrenal
Left Kidney
Artery
Vein
Ureter
Cardiac end
Right Kidney
Urinary Bladder
Ovary
Fallopian tube
Spleen
Uterus
Left Uterus cut
Tail
Gall Bladder
Pylorus
Abdominal Wall
Hairy Integument
Hind-limb
4 Digits
Duodenum
Duct of Pancreas
Ileum
Appendix Vermiformis
Sacculus rotundus
Cæcum
Fig. 2 Secreting Corpuscles of Submaxillary gland
Fig. 3 Lobule of Parotid gland
Fig. 4 Vertical Section of Ileum (highly magnified)
Brunner's gland
Lieberkühnian glands
Villi
Fig. 5 Portion of Ileum Showing Valvulæ conniventes

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PLATE XIX.—THE RABBIT—*continued.*

SECTION OF FROZEN RABBIT.

Freezing of Rabbit.—As this is the type of a process which the student will find it convenient to use, I will describe it fully. The following description applies only to the Rabbit, but there should be no difficulty in adapting the process to other animals.

The Rabbit was killed (in this instance in the ordinary way by a smart blow behind the ears) and at once skinned roughly, then placed in a small tin box of sufficient size to hold it, with a lid. A good-sized pail was taken, having a hole towards the bottom plugged so as to let out the water from the melting ice when necessary. The tin box containing the Rabbit was placed in this pail with a mixture of ice and salt below, around, and above it, the whole covered with a coarse sack or some such thing. The ice was pounded roughly, and coarse salt scattered plentifully amongst it as it was thrown into the pail. In three hours the Rabbit was frozen as hard as a stick, but it was allowed to remain another hour for perfect safety. About the middle of the process the plug was taken out and the water from the melting ice allowed to run off, a fresh supply of ice and salt being added to make up for the loss, then the whole covered up as before. When taken out the Rabbit could be freely handled, as it was quite hard, and with a fine-toothed saw it was cut through as near as possible in the middle line.

A *young* Rabbit was necessarily chosen to suit the size of plate.

The section of the head was made a little to one side, so the incisor teeth are not shown. The brain was washed with a camel-hair brush dipped in water, in order to bring out the division of parts clearly. I may add that in my first attempts at freezing with the ice-cream machine I tried to do a couple of Rabbits (male and female) at once, merely separating them by a temporary wooden partition, but neither of them froze properly.

INTERNAL PARTS IN THEIR NATURAL SIZE AND RELATIONS—

Skeleton
- Sternum, ending in xiphoid process, showing the cut ends of the seven sternal ribs.
- Spinal column, showing seven cervical, twelve dorsal, seven lumbar, four sacral, and a few caudal vertebræ.
- Skull, showing cranial and facial portions.
- Mandible, a small portion seen.
- Hyoid, at root of tongue.
- Pubis, the ventral portion of hip-girdle.

Nervous system
- Brain—
  - Medulla oblongata, lying on basi-occipital (B. O.).
  - Cerebellum, resting on dorsal surface of medulla.
  - Optic lobes, or corpora quadrigemina (L. the four paired bodies), consisting of a posterior pair or testes, and an anterior larger pair or nates.
  - Optic thalami connected by commissures, the large middle one seen.
  - Pituitary body attached to infundibulum, and lying in a hollow of the basi-sphenoid (B. S.).
  - Cerebral hemisphere ending anteriorly in olfactory lobe.
- Spinal cord, ending a little beyond sacrum.
  - In killing the Rabbit the skull was severed from the spinal column, and the spinal cord from the brain, so that the natural junction and thickness at this part was interfered with.

Alimentary system
- Mouth—Tongue in floor.
  - Palate or roof with transverse ridges.
  - Pharynx, the back portion leading into gullet.
- Posterior nares opening a little above posterior end of palate.
- Gullet passing above trachea, between lungs, and through diaphragm to stomach.
- Stomach (the larger cardiac portion on left side being removed), showing three distinct coats—
  - Outer peritoneum.
  - Middle muscular layer.
  - Inner lining of mucous membrane.
- Intestine in numerous folds bound up and suspended by mesentery.
- Cæcum with internal projections from wall, corresponding to outer spiral markings.
- Colon between two folds of cæcum.
- Rectum extending from anterior end of abdominal cavity, with black pellets of fæcal matter.
- Anus, with hairless spaces on each side.
- Liver showing right central and caudate lobes.
- Spleen, transversely elongated, the greater part being on left side.

Diaphragm arching from the base of the sternum to the region of the kidney, the heart and lungs being in relation with it on one side; the liver, stomach, and kidney on the other.

Heart enclosed in its membrane or pericardium, its base covered with fatty matter, and the thymus gland (Gr. *thumos*, heart) for storing up fat.

Respiratory system
- Glottis, the opening through larynx into trachea.
- Trachea passing beneath gullet and dividing; root of left bronchus shown.
- Lung lying along dorsal wall of thoracic cavity, enclosed in its membrane or pleura.

Urino-genital system
- Right kidney embraced by caudate lobe of liver, with adrenal on inner face.
- Ovary in relation with kidney.
- Vagina with bladder on ventral surface.
- Urino-genital aperture immediately in front of anus, but not seen.

Section of Frozen Rabbit — right side
Female

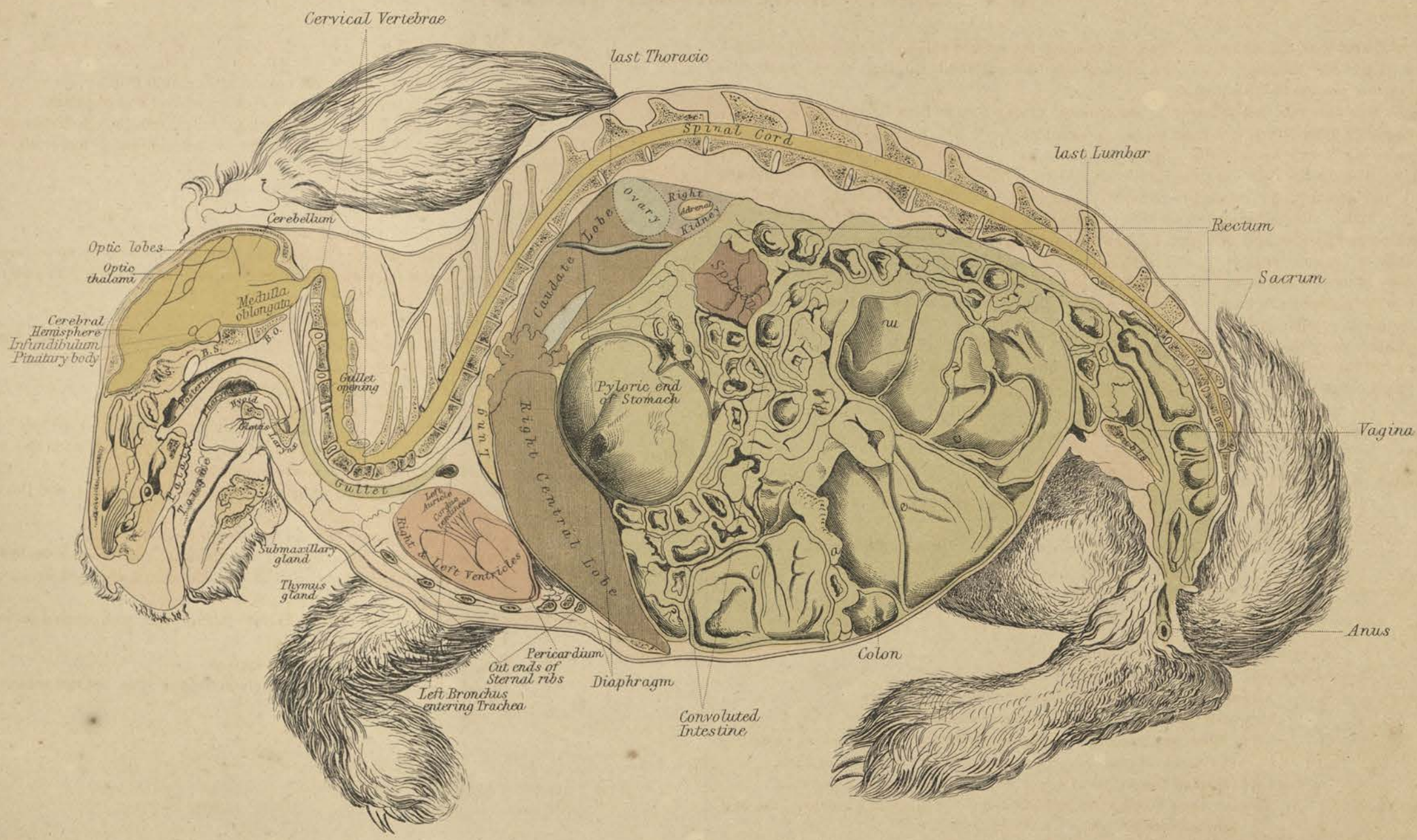

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PLATE XX.—THE RABBIT—*continued.*

SKELETON.

EXOSKELETON—

FIG. 1. Hair, an epidermal structure arising in a depression and swollen at the base.
Cortical or outside layer forming a tube with cross partitions.
Fat-cells escaping serve to lubricate the hair.
Epidermis, consisting of several layers of cells which become flattened towards the surface.

ENDOSKELETON—

Prepare skeleton by boiling, detach skull from spinal column, and run a flexible wire through the spinal canal as far as the sacrum. The cleaning of the bones may then be proceeded with, as the vertebræ will be kept in order on the wire as they are separated.

FIG. 2. Cervical vertebræ, seven, as in all Mammals with few exceptions.

Atlas . . . . { Centrum, a narrow transverse bridge with articular surface on top for odontoid process.
Neural arch, broad, pierced by first spinal foramina.
Transverse processes, wing-like, with vertebrarterial canal at base.
Articular surfaces for skull, large and spreading.

FIG. 3.

Axis . . . . { Centrum, with odontoid process, having articular surfaces below and on each side of base fitting on to corresponding surfaces on atlas.
Neural arch with greatly developed spine overhanging neural arch of atlas, and articular surfaces on posterior face of arch only (posterior zygapophyses).
Transverse processes, backwardly directed points with vertebrarterial canal at base.

FIG. 4. Dorsal or thoracic vertebræ, twelve, bearing ribs.

Second thoracic . { Centrum with half facets anteriorly and posteriorly for capitula of ribs. The heads of the ribs are at the junction of two centra, hence the half-facet arrangement.
Neural arch, low, with backwardly projecting spine, and anterior and posterior zygapophyses.
Transverse processes giving attachment to tuberculum of rib.

FIG. 5. Twelfth thoracic, note—
Last rib attached entirely to anterior end of vertebra.
Transverse process very small.

Neural arch . . { Short and laterally compressed spine pointing forwards.
Metapophyses, or mamillary processes, at anterior end.
Anapophyses at base and posterior.

FIG. 6. Lumbar vertebræ, seven.
First lumbar, note—
Transverse processes large, pointing downward and forward.
Metapophyses also large.
Hypapophysis, a median spine on under surface of centrum.
Anapophyses, small projections at posterior end.

FIG. 7. Sacral vertebræ, three or four commonly imperfectly fused to form sacrum—
First attached to ilium by oblique faces of lateral expansions.
Second attached by expanded anterior end.
Caudal vertebræ, fifteen (in specimen examined), are like the sacral to begin with, but diminish in size gradually towards the tip of the tail.

FIG. 8. Sternum composed of five segments or sternebræ giving attachment to ribs, the anterior segment distinguished as presternum or manubrium (L. a handle), which is keeled, and the posterior segment attached to the xiphisternum, which ends in a plate of cartilage.
Sternal ribs, seven; these with the attached vertebral ribs make up the *true* ribs, in contradistinction to those *false* ribs which do not reach the sternum directly.

FIG. 9. Pectoral arch—
Scapula triangular, with cartilaginous supra-scapula, and a spine ending in large acromion process (Gr. *akron*, the summit; *omos*, shoulder) and metacromion.
Coracoid, a little hooked process.
Clavicle attached to acromion and presternum by fibrous tissue. A slightly curved bone about three-quarters of an inch in length and readily overlooked (clavicle not marked off from fibrous tissue in drawing).
Fore-limb—
Humerus with rounded head, tuberosities (greater and lesser), and deltoid ridge for insertion of deltoid muscle.
Radius and ulna fixed, the latter ending in anconeal (Gr. *ankon*, the elbow) or ole'cranon process (Gr. *olene*, elbow).

Manus . . { Carpus { Proximal row—Scaphoid and lunar articulating with radius. Cuneiform with ulna.
Middle—Centrale.
Distal row—Trapezium.
Trapezius or trapezoid.
Magnum, the smallest.
Unciform.
Metacarpus—The two outer metacarpals articulating with unciform, as in all Mammals.
Digits—Pollex consisting of two joints or phalanges, others of three.

FIG. 7—*continued.*—Pelvic arch, or pelvis, composed of two innominate bones.
Ilium articulated with sacrum.
Ischium in a line with ilium.
Pubis, the ventral margin of obturator foramen.
Acetabulum, in the centre of which is seen in the young rabbit the tri-radiate junction of these three separate bones.

FIG. 10. Hind-limb—
Femur with rounded head and trochanters (greater, lesser, and third) for attachment of muscles.

Sesamoid bones formed in tendon . . . { Patella (L. a plate), or kneecap, ossified and attached by ligament to tibia.
Fabella behind condyle of femur.

Tibia with prominent crest and the slender fibula fused with it near its middle.

Pes . . . . . { Tarsus { Proximal row—Astragalus or ankle-bone.
Calcaneum or heel-bone with articular surface near the middle.
Middle—Navicular.
Distal row—Mesocu'neiform.
Ectocuneiform.
Cuboid.
Metatarsus—The two outer metatarsals articulating with cuboid.
Digits—Three phalanges in each, hallux awanting.

Fig 1. Hair imbedded in Skin

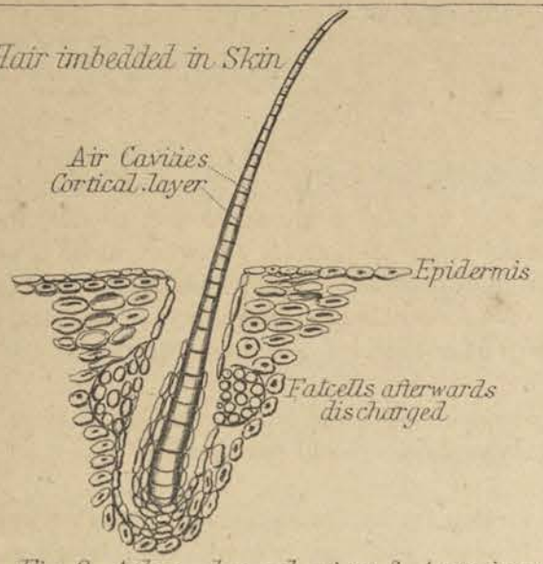


Fig 2. Atlas - dorsal view & Anterior face

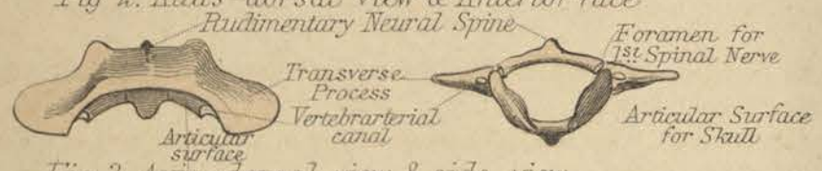


Fig 3. Axis - dorsal view & side view

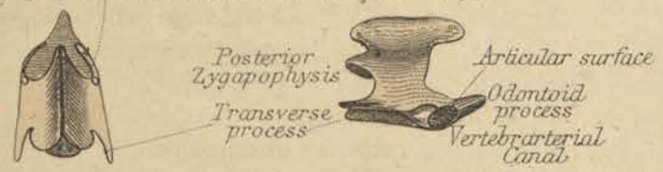


Fig 4. 2nd Thoracic (Anterior face)

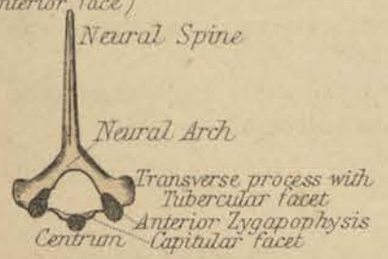


Fig 5. 12th (last) Thoracic - side view

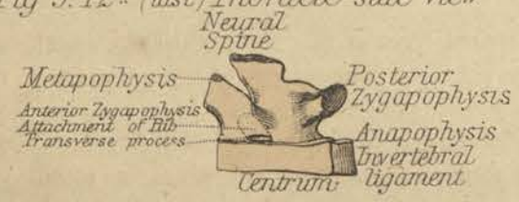


Fig 6. 1st Lumbar - anterior face

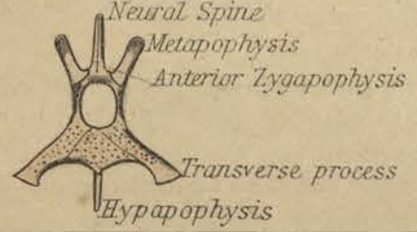


Fig 8. Sternum & Sternal Ribs (Ventral View)

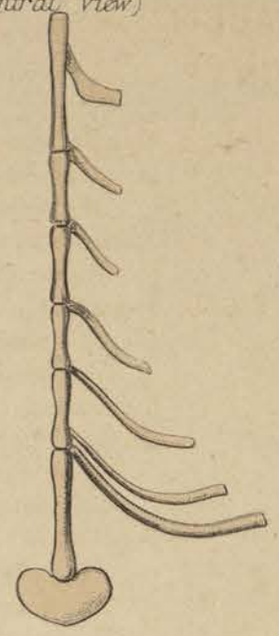


Fig 7. Pelvis with Sacral Vertebræ (Ventral View)

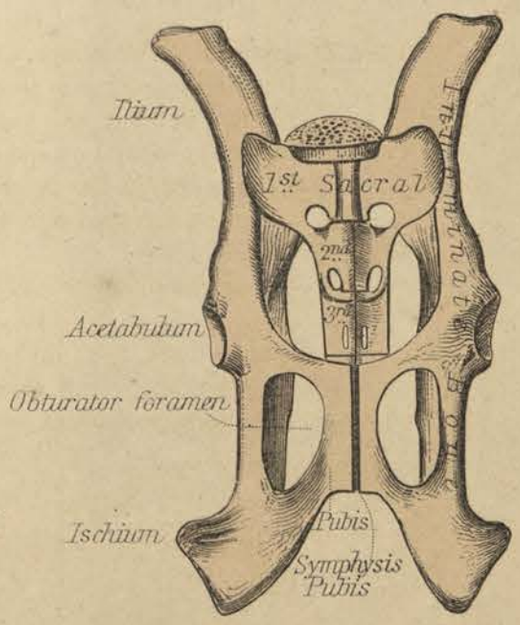
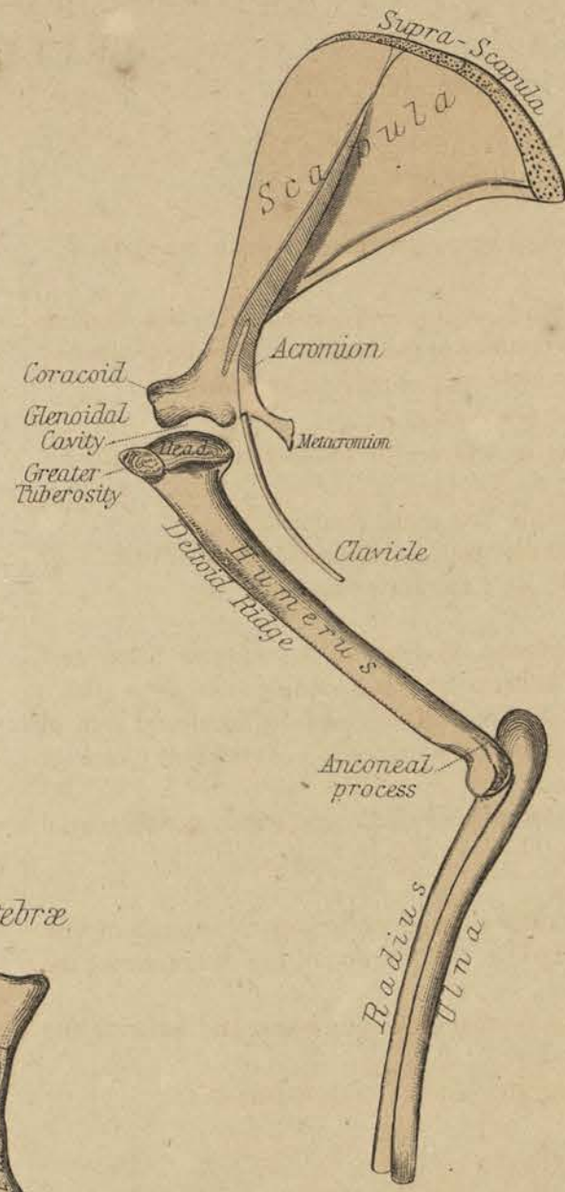


Fig 9. Left half of Shoulder-girdle With fore-limb - outer view



Dorsal Surface of Manus

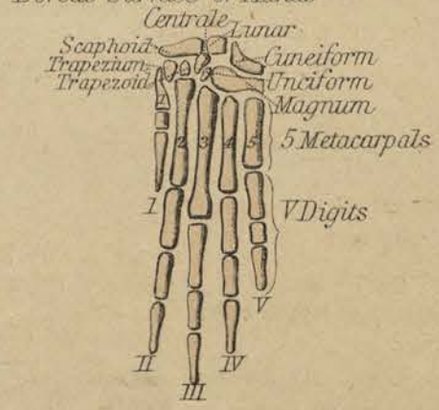
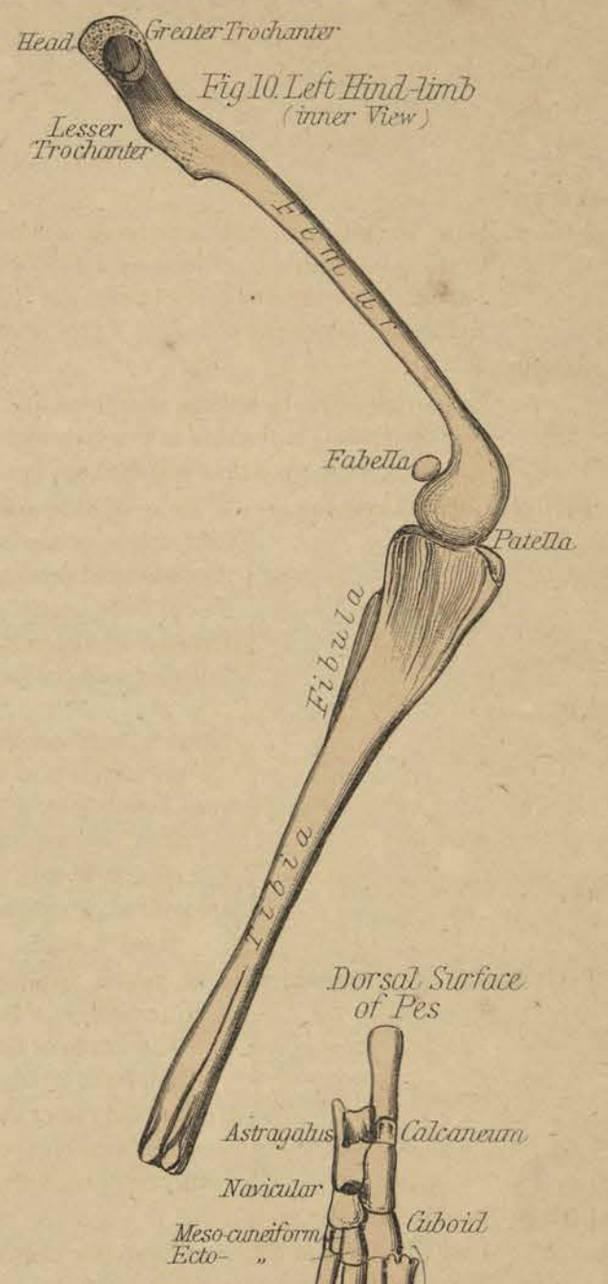
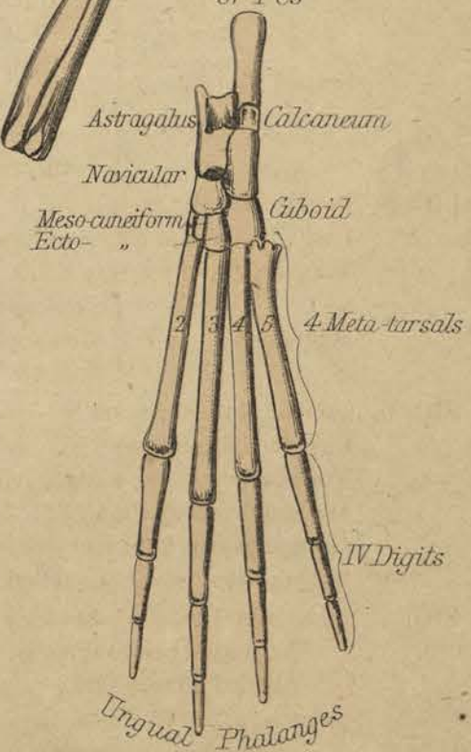


Fig 10. Left Hind-limb (inner View)



Dorsal Surface of Pes



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THE SKULL AND ITS DEVELOPMENT.

FIGS. **1** and **2.** The bones of the skull may be made out separately as seen in the different views, then grouped together as follows :—

- Occipital segment (in adult fused into single occipital bone) . .
  - Basi-occipital forming boundary of foramen magnum and portions of occipital condyles.
  - Ex-occipitals, each with a par-occipital process and condylar foramen for XII. nerve.
  - Supra-occipital forming upper boundary of foramen magnum.
- Inter-parietal between the parietals and central shield-like portion of supra-occipital.
- Parietal segment . . . . . .
  - Basi-sphenoid, broad behind, tapering in front.
  - Ali-sphenoids, wing-like bones fused to either side of basi-sphenoid.
  - Parietals with sagit'tal suture, with an inner and outer pterygoid process meeting and uniting between, which diverges behind to form lambdoidal suture (Gr. letter λ (*l*), called lambda).
- Frontal segment . . . . . .
  - Pre-sphenoid bounding the optic foramen anteriorly.
  - Orbito-sphenoids, wing-like bones fused to either side of pre-sphenoid, and bounding the optic foramen posteriorly.
  - Frontals with frontal suture between, and transverse coronal suture behind (L. *corona*, a crown). A supra-orbital process projects on each side, and an orbital process curves inward and downward for each orbit.

Vomer, a median bone between maxillæ.

Maxillæ, outer surface spongy, uniting posteriorly with jugal or malar bone (L. *mala*, cheek-bone), lower surface bearing teeth, and inner surfaces united behind by a palatine process from each.

Zy'goma or zygomatic arch (Gr. *zugos*, a yoke) consists of the malar, which unites with maxilla in front, and passes backward *beyond* zygomatic process of squamosal (an exceptional occurrence) to form outer *border* of glenoid fossa.

Pre-maxillæ, each giving off a nasal process extending to frontal.

- Region of nose . . . . . .
  - Nasals overlying nasal cavities.
  - Mesethmoid and parethmoids (see fig. 2).

Lachrymals, in anterior wall of orbit, usually dropping out in the dry skull.

Squamosal giving off a slender process posteriorly, and a zygomatic process at the side, with articular surface for lower jaw—the glenoid fossa.

- Region of ear. . . . . .
  - Tympanic, composed of tubular meatus (L. passage) directed backwards and outwards, and tympanic bulla (L. a bubble), the blown-out portion below.
  - Periotic fused to inner side of tympanic.
- Palato-pterygoid . . . . . .
  - Palatines diverging posteriorly and ensheathing united processes of ali-sphenoid, and anteriorly uniting in the middle line to form half of bony palate.
  - Pterygoids, represented by the internal pterygoid processes of ali-sphenoids.
- Ramus of mandible . . . .
  - Condyle articulating with squamosal.
  - Coronoid process small and curving inwards.
  - Angle rounded and curving inwards.
  - Symphysis where the two rami articulate, extending to beneath first pre-molar.

Teeth—Incisors, two in each pre-maxilla and one in each ramus: The inner upper incisors are small and fit against lower. Canines, absent. Pre-molars are those molars or grinding teeth which have had predecessors. There are three in each maxilla and two in each ramus. Molars, three on each side above and below.

Dental formula—$i.\ \frac{2-2}{1-1}$, $p\text{-}m.\ \frac{3-3}{2-2}$, $m.\ \frac{3-3}{3-3} = 28$.

FIG. **2.** The following points can only be seen in section :—

Floccular fossa, a deep depression in periotic lodging flocculus of cerebellum.

Sella Turcica (Turkish saddle), or pituitary fossa, a hollow in upper surface of basi-sphenoid lodging pituitary body.

- Mesethmoid . . . . . .
  - Cribriform plate (L. *cribrum*, a sieve) perforated for the passage of olfactory nerves arising from olfactory lobes.
  - Lamina perpendicularis (L. perpendicular plate) anterior to cribriform plate, and together with the cartilaginous septum nasi (partition of the nose) separating the two nasal cavities.
- Turbinals or folded bones (L. *turbo*, I twist) . . . . . .
  - Ethmo-turbinals or parethmoids on either side of mesethmoid and fused therewith.
  - Naso-turbinals, the inner surface of the nasals produced into thin plates.
  - Maxillo-turbinals at entrance of nose.

DIAGRAM **1.** Showing—

The bones of the skull and their relative position to the foramina for the exit of the cranial nerves.

Cranio-facial angle, the obtuse angle formed by the cranial and facial portions respectively of the cranio-facial axis.

- Hyoid arch . . . . . Tympano-hyal, from its relation to tympanic bone (dotted).
  Stylo-hyal.
  Epi-hyal.
- Hyoid small and loosely attached in Rabbit, represented only by these three pieces . . . .
  - Cerato-hyal, a small anterior pair.
  - Basi-hyal, or body of hyoid, keeled in front.
  - Thyro-hyal, from its close relation to thyroid cartilage of larynx, a long posterior pair.

FIG. **3.** Remove the outer wall of tympanic and observe ear-bones in position, the stapes inserted into fenestra ovalis, and fenestra rotunda anterior to that. Detach, examine, and preserve in pill-box.

Malleus (L. hammer), round head articulating with saddle-shaped surface of incus.

Incus (L. anvil) giving off two processes, to the longer of which is attached—

Orbicular (L. *orbiculus*, a little circle).

Stapes (L. stirrup), the broad base inserted into fenestra ovalis and the top articulated with orbicular.

DIAGRAM **2** (after Huxley). Showing the relation of the Mammalian ear-bones, and their representatives in the lower Vertebrata.

Fishes.		*Lizards.*		*Mammals.*
Quadrate	=	Quadrate	=	Malleus.
Hyomandibular	=	Supra-stapedial of Hyoid	=	Incus.
——		Columella auris	=	Stapes.

DIAGRAM **3** (after Parker).

Notocord passing between paracordals to posterior end of trabeculæ.

Paracordal portion (Gr. *para*, beside), two plates uniting above and below to form occipital segment.

Auditory capsule developed round the organ of hearing, afterwards fusing with paracordals.

- Visceral arches common to the embryonic form of all Vertebrata . . . . . .
  - Trabeculæ (L. little rafters), each separate rods of cartilage at first, afterwards coalescing anteriorly, forming floor, sides, and to a certain extent top of anterior portion of skull.
  - Mandibular arch, consisting of an upper palato-pterygoid portion forming palatine and pterygoid principally, and a lower mandibular portion forming lower jaw.
  - Hyoid arch, becoming incus at its upper extremity, lower extremity supporting tongue.

Fig 1. Skull

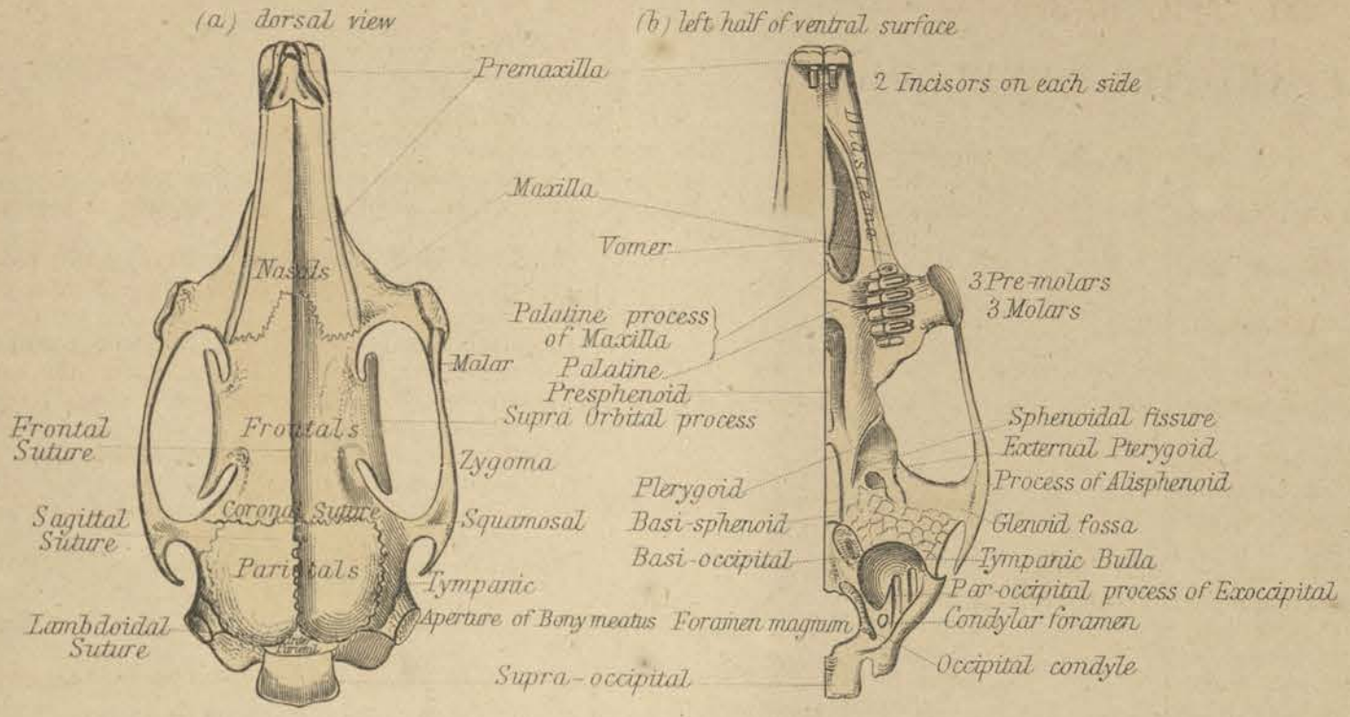
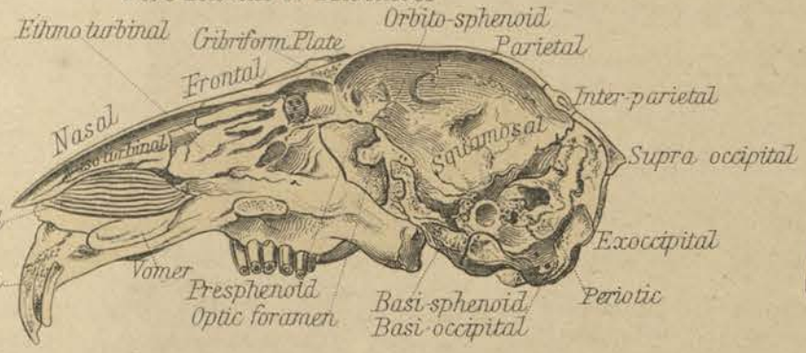
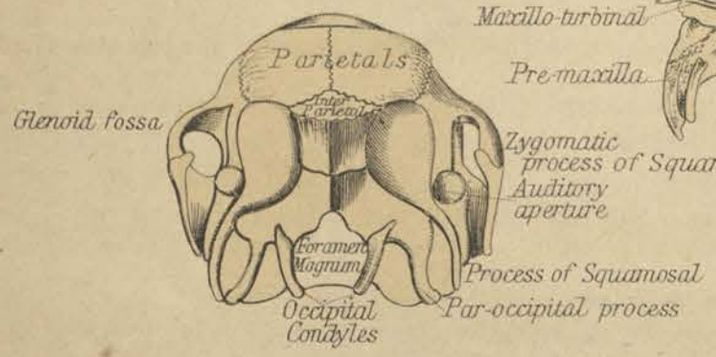


Fig 2. Longitudinal Vertical section of Skull with Ramus of Mandible



(c) Posterior View



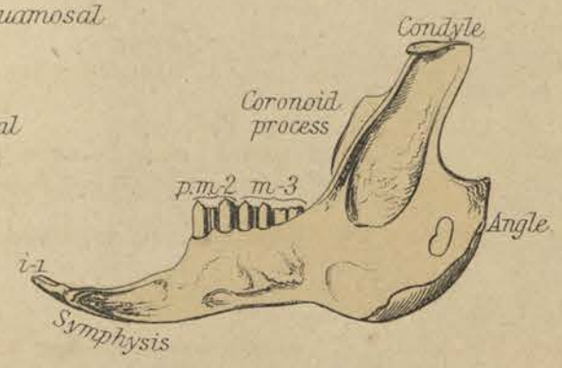


Diagram 1. Bones of Mammalian Skull

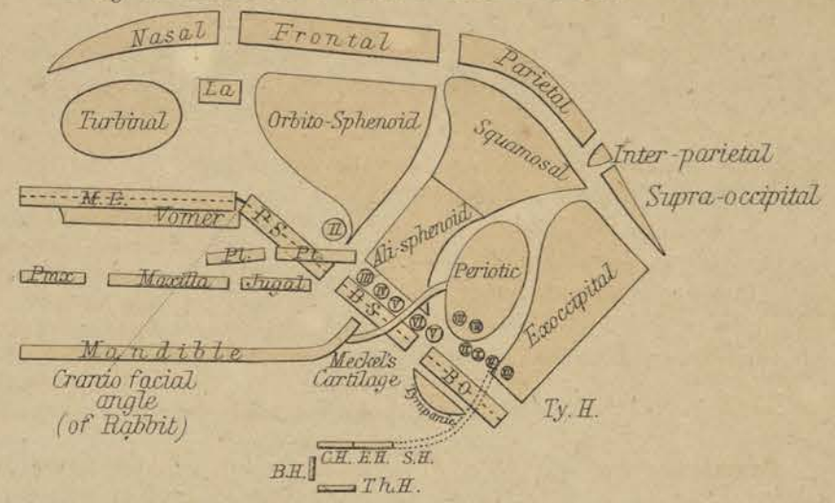


Fig 3. Ear bones enlarged-relative sizes

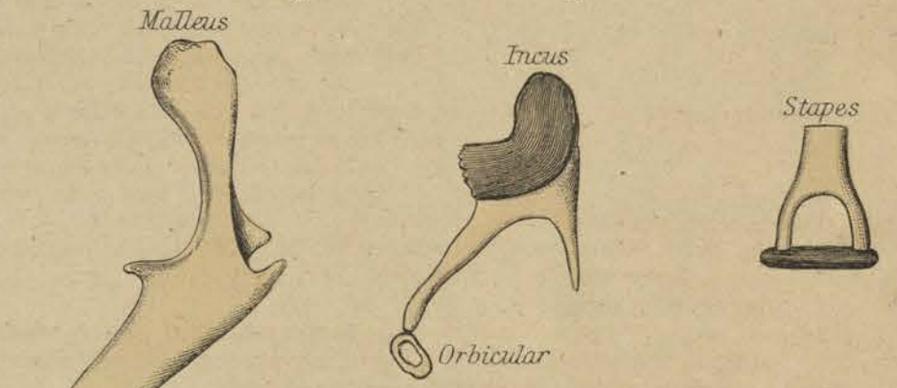


Diagram 3. Development of Skull

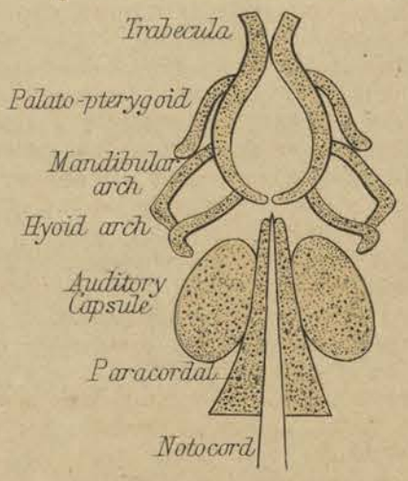


Diagram 2. Mandibular & Hyoid Arches showing origin of Ear-bones

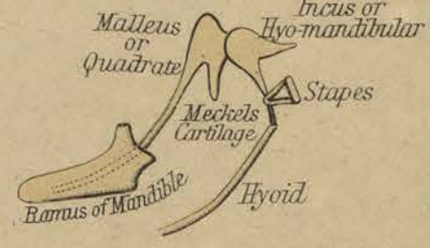


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PLATE XXII.—THE RABBIT—*continued.*

NERVOUS SYSTEM AND SENSE-ORGANS.

FIG. 1. Medulla oblongata with the posterior pyramids in the middle line.
Cerebellum much convoluted and divided into three lobes, central and lateral. The flocculi project outwardly from each lateral lobe.
Pineal gland round and vascular.
Cerebral hemispheres with surface depressions, or sulci (L. furrows), and indications of three lobes in each hemisphere. *Parietal* in contact with cerebellum, *Temporal* at the side, passing into *Frontal* at anterior end.

FIG. 2. Anterior pyramids of medulla oblongata, two ridges on either side of the middle line.
Pons Varolii (L. bridge of Varolus), a transverse band of fibres connecting lateral lobes of cerebellum.
Crura cerebri, two obliquely directed bands of fibres.
Corpus mammillare, or corpus albicans (L. whitish body), a roundish body.
Infundibulum, or stalk of the pituitary body.
Optic chiasma, a transverse band giving off the two optic nerves.
Sylvian fissure at the junction of the temporal and frontal lobes.
Olfactory lobes (I.) projecting from ventral surface of hemispheres.

ORIGIN OF NERVES—

I. Olfactory, from extremities of olfactory lobes.
II. Optic, from optic thalami.
III. Oculo-motor, from crura cerebri.
IV. Pathetic, from valve of Vieussens.
V. Trigeminal, from pons Varolii.
VI. Abducent, from anterior pyramids.
VII. Facial, from medulla oblongata posterior to V.
VIII. Auditory, immediately behind VII.
IX. Glossopharyngeal, from posterior portion of medulla.
X. Pneumo-gastric, close behind IX.
XI. Spinal accessory added to by nerve fibres from spinal cord.
XII. Hypoglossal, from the commencement of medulla.

FIG. 3. Corpus striatum (L. striped body), a projection forming floor of anterior cornu of each lateral ventricle.
Tænia semicircularis (Gr. *tainia*, a ribbon or band), on which lies the choroid plexus, a highly vascular membrane.
Posterior pillar of fornix (L. an arch) arising from body of fornix, and running posteriorly along hippocampus major.
Fissure of Bichât between the two preceding.
Hippocampus major, a projection into descending cornu of lateral ventricle.
Septum lucidum (L. clear partition), a double membrane enclosing the narrow fifth ventricle, and separating the anterior portion of lateral ventricles.

Commissures:
- Anterior (exposed by cutting away a portion of hippocampus major) connects corpora striata.
- Middle, connects optic thalami.
- Posterior, immediately anterior to pineal gland.

Ventricles (only 3rd shown):
- Fourth ventricle, between the posterior pyramids and beneath cerebellum.
- Aqueduct of Sylvius, narrow passage between third and fourth.
- Third ventricle, opening anteriorly into each lateral ventricle by foramen of Monro.
- Lateral ventricles (first and second), the cavity of each cerebral hemisphere.
- Fifth ventricle, a narrow cleft in anterior portion of septum lucidum.

FIG. 4. Spinal cord deeply grooved dorsally and ventrally, with a central canal surrounded by grey matter prolonged at four corners into the dorsal and ventral roots of spinal nerves, white matter forming rest of cord.

FIG. 5. Tease out grey matter, and observe nerve-cells with branched processes.

FIG. 6. Nasal bones roofing nasal cavity, and produced inferiorly into naso-turbinals.
Ethmo-turbinals on either side of mesethmoid, which separates the two nasal cavities.
Organ of Jacobson, a canal in base of each nasal cavity.

FIG. 7. The organ of Jacobson is a shut tube behind, but opens in front into mouth, and is lined with epithelial cells upon which a branch of the olfactory nerve is distributed.

FIG. 8. Olfactory cells with outer fine processes, and inner connected with olfactory nerve.
Epithelial cells between, broad outwardly and linear inwardly.

FIG. 9. Superior oblique muscle with its pulley arrangement, becoming tendinous where it passes through the loop.

FIG. 10. Remove a little of the retina from the eye, and a pigment-layer will be exposed. Detach a piece, mount in glycerine, and the hexagonal cells will be seen.

Fig. 1 Brain
(Dorsal Surface)

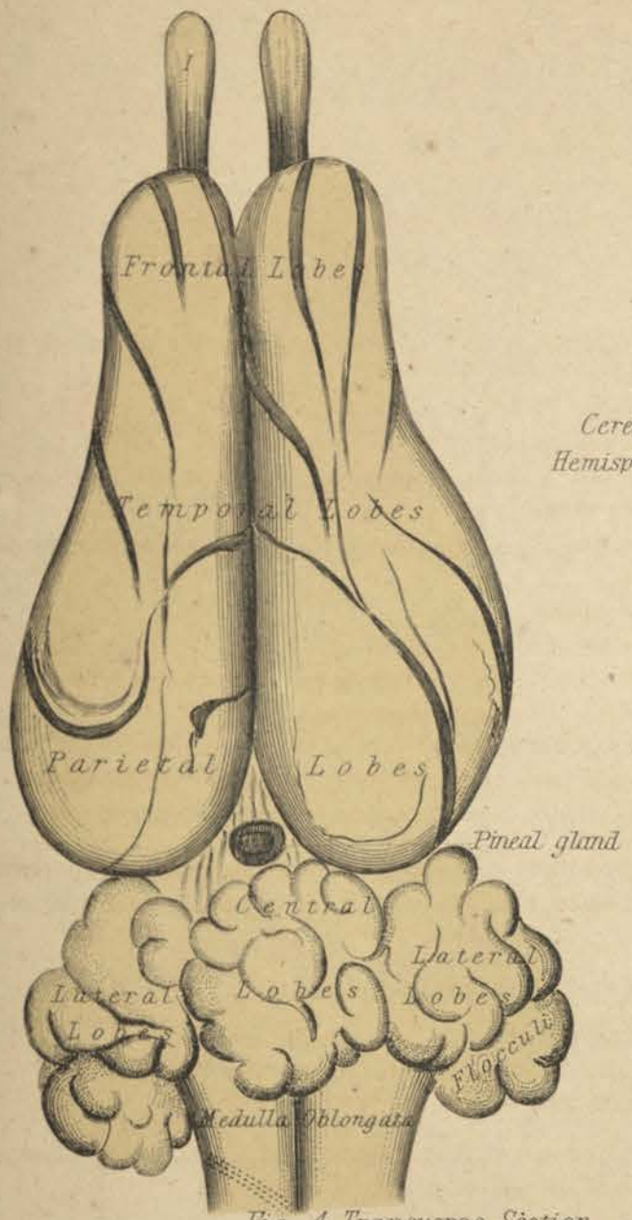

Fig. 2 Brain
(Ventral Surface)

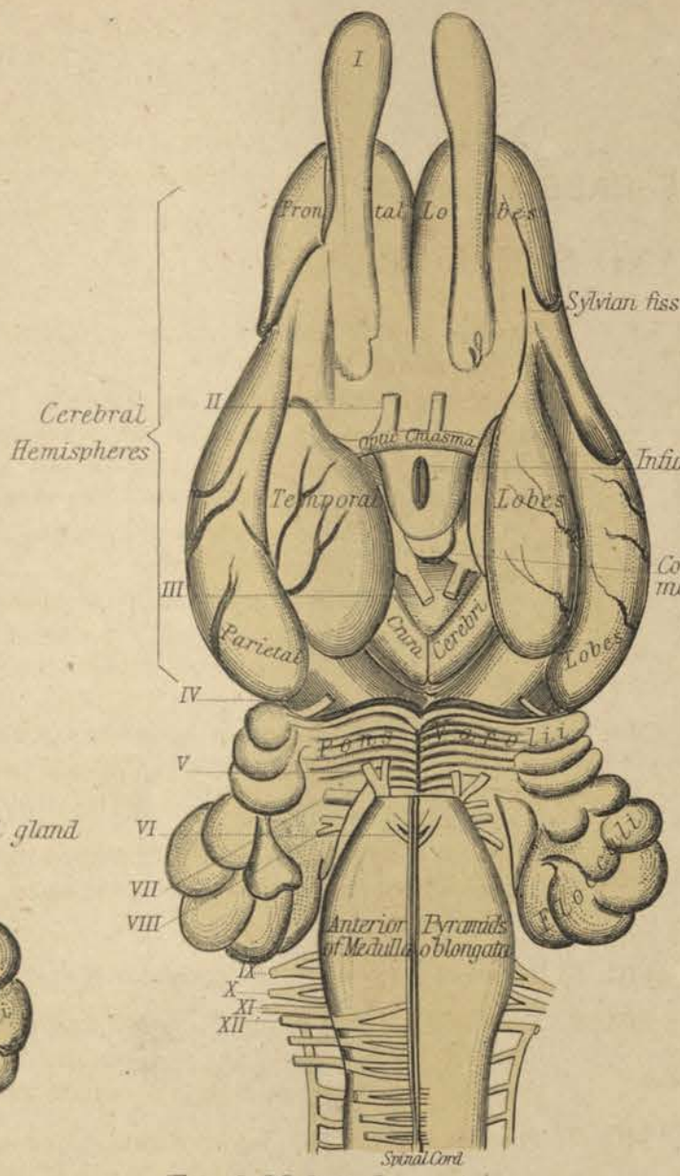

Fig. 3 Brain
(Cerebral Hemispheres laid open)

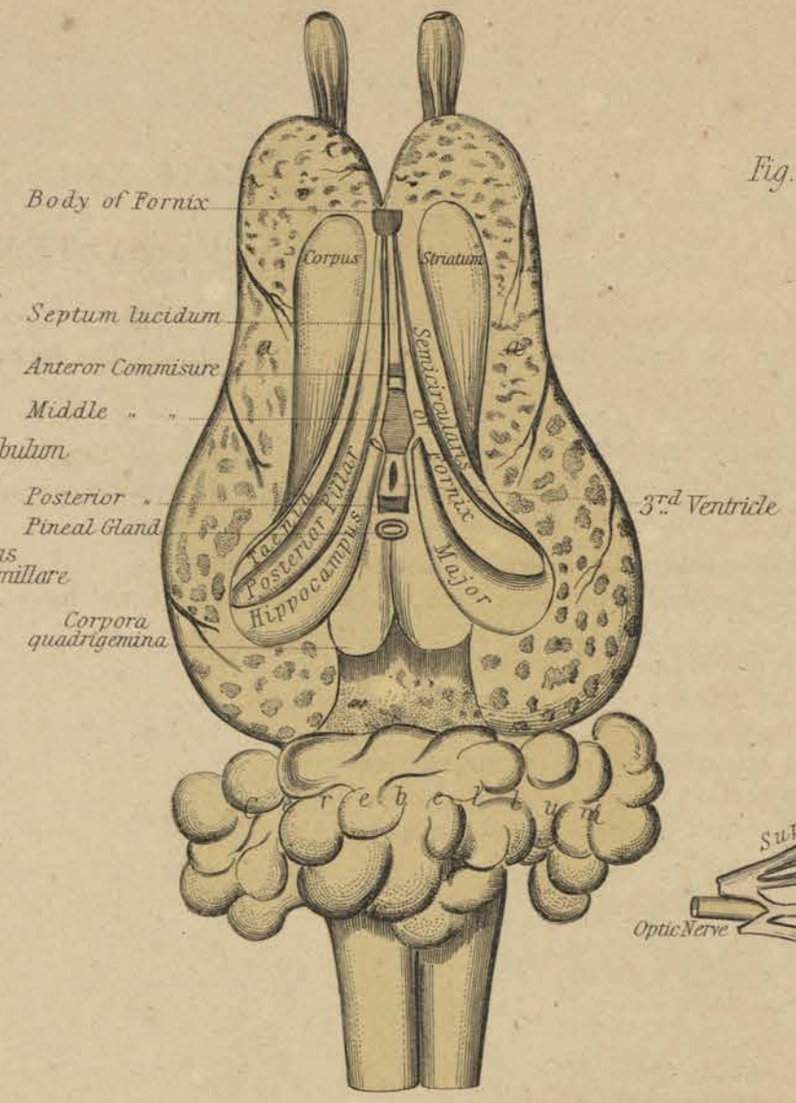

Fig. 10 Black Pigment Cells
from Choroid Coat of Eye

Fig. 9 Muscles of Eye
(side view)

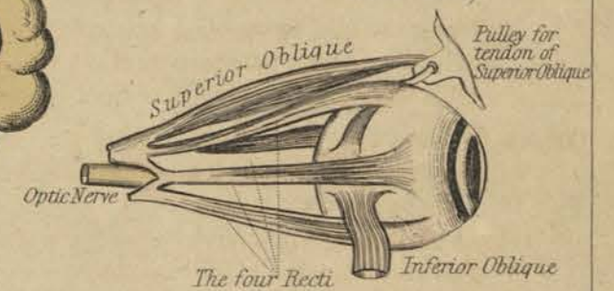

Fig. 4 Transverse Section of Spinal Cord

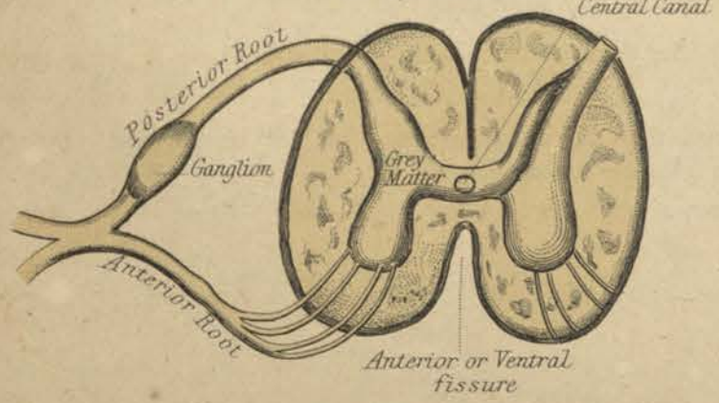

Fig. 5 Multipolar Nerve Corpuscle

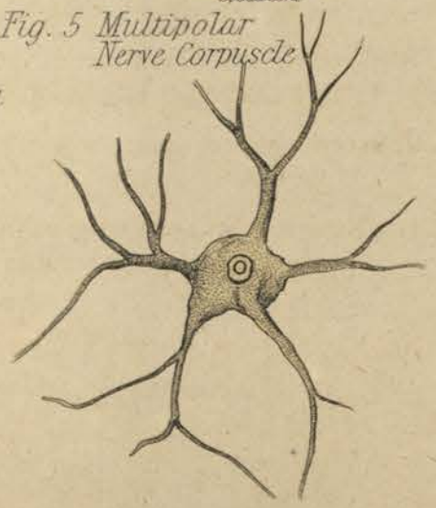

Fig. 6 Vertical Section of Nasal Chamber

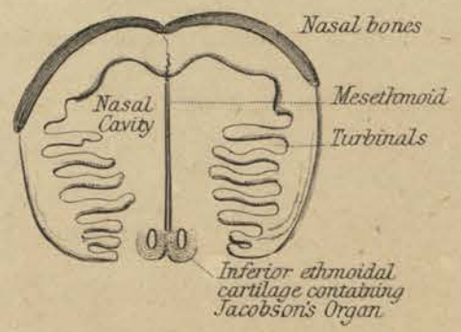

Fig. 7 Jacobson's Organ
(enlarged)

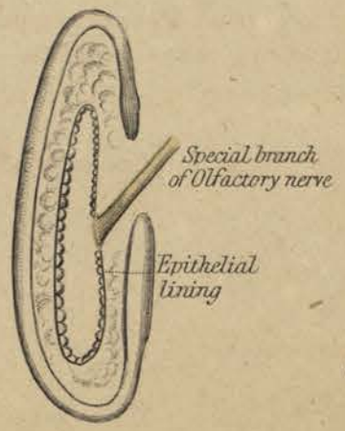

Fig. 8 Olfactory Cells

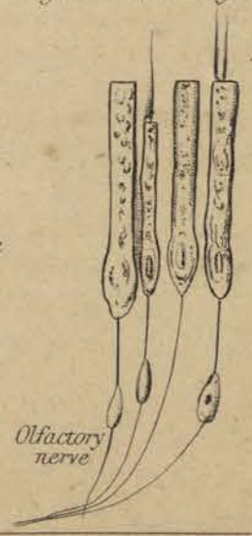

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PLATE XXIII.—THE RABBIT—*continued.*

CIRCULATION.

FIGS. 1 and 2. Remove pericardium surrounding heart, and trace out the blood-vessels going towards the head and fore-limbs. Next follow the course of the aorta and inferior vena cava, with their various branches towards the tail and hind-limbs.

Heart . . . { Right and left auricles, thin walled.
Right ventricle, marked off externally from the left by a depression.
Left ventricle, forming entire apex or point of heart.

Arteries.—The aorta forms the chief arterial trunk. It arches over to the left, and descends beneath the vertebral column to the posterior extremity of the body. The arteries arising from it are as follows:—

Left aortic arch (fig. 2) {
- Innominate, arising from right side of aortic arch, and giving off left carotid, and dividing into right carotid and right sub-clavian.
- Left sub-clavian, arising from left side of aortic arch.
- Carotids, each divides into an external carotid going to head, and an internal carotid going to brain.
- Sub-clavians, each divides into a vertebral artery going through vertebrarterial canal to spinal cord and brain, and a brachial artery going to fore-limb.

Dorsal aorta . {
- Cœliac, giving off { Hepatic to liver. Splenic and gastric to spleen and stomach.
- Superior mesenteric, to small and large intestine.
- Lumbar arteries, to lumbar region of body.
- Renal arteries, to kidneys.
- Inferior mesenteric, to rectum.
- Spermatic arteries, to generative organs.
- Common iliac arteries, formed by the forking of aorta, each giving off an ilio-lumbar artery, then dividing into internal and external iliac.
- Femoral, a continuation of the external iliac into leg.

Pulmonary artery dividing for each lung and connected to aorta by ligament, the ductus arteriosus of fœtal life.

Veins—

Superior vena cava, receiving . . . {
- External jugular from head.
- Internal jugular from brain.
- Sub-clavian from arm.
- Azygos, receiving intercostal veins from between the ribs.
- Superior phrenic (Gr. *phren*, the diaphragm) from diaphragm.

Inferior vena cava, arising from common iliac, and two external iliac veins . . . . {
- Femoral veins from legs passing into—
- External iliac veins, one on each side.
- Two internal iliac veins uniting and forming—
- Common iliac vein.
- Ilio-lumbar veins.
- Spermatic veins from generative organs.
- Lumbar veins.
- Inferior phrenic from diaphragm.
- Hepatic veins (not shown) from liver.

Portal vein (not shown) formed by and breaking up in liver. {
- Mesenteric from intestine.
- Splenic and gastric from spleen and stomach.

Pulmonary veins, two from each lung entering left auricle.

FIG. 3. Remove heart, taking care to have portions of great vessels attached. Blow into the cut ends of the vessels with a pipette, and insert rods to keep them distended. Lay out under water, and examine dorsal surface.

FIG. 4. Fasten out heart with right side uppermost, and cut into right auricle without injuring the vessels entering it. Then expose cavity of right ventricle by a V-shaped incision.

Right auricle, receiving three venæ cavæ—right and left superior and inferior.
Left auricle, receiving pulmonary veins.
Right ventricle, giving off pulmonary artery.
Left ventricle, giving off aorta.
Tricuspid valve (L. *tres*, three; *cuspis*, a peak), the right auriculo-ventricular valve consisting of three flaps, and attached to little elevations on wall of ventricle by the chordæ tendineæ.
Columnæ carneæ (L. fleshy columns), ridges on inner wall of ventricle.
Semi-lunar valves, three at origin of pulmonary artery and also of aorta.

FIG. 5. In a vein of the fore-limb, for instance, examine the *valves*, and test their action by causing water to flow in them in a direction away from the heart.

CLASSIFICATION—

Sub-Kingdom—Vertebrata.

Class—Mammalia (L. *mamma*, a teat)—
- Hairs possessed at some time or other of life.
- Mammary glands secreting milk.
- Skull with two occipital condyles.
- Mandible articulating directly with the squamosal portion of skull.
- Cervical vertebræ, seven (with three exceptions).
- Heart four-chambered, with *left* aortic arch.
- Red blood-corpuscles non-nucleated.
- Diaphragm forming a complete fibro-muscular partition.

Natural Order—Rodentia (L. *rodo*, I gnaw)—
- Dorso-lumbar vertebræ, usually 19.
- Incisor teeth chisel-shaped, a pair above and below (Rabbit and Hare are exceptional in possessing two on each side above).
- Canines absent.

Family—Leporidæ (L. *lepus*, a Hare)—
- Incisors, two pair above; posterior pair smaller.

Genus—Lepus.

Species—L. cuniculus (L. *cuniculus*, a Rabbit) and L. timidus, the Hare, etc.

Fig 1. Circulation - Ventral view

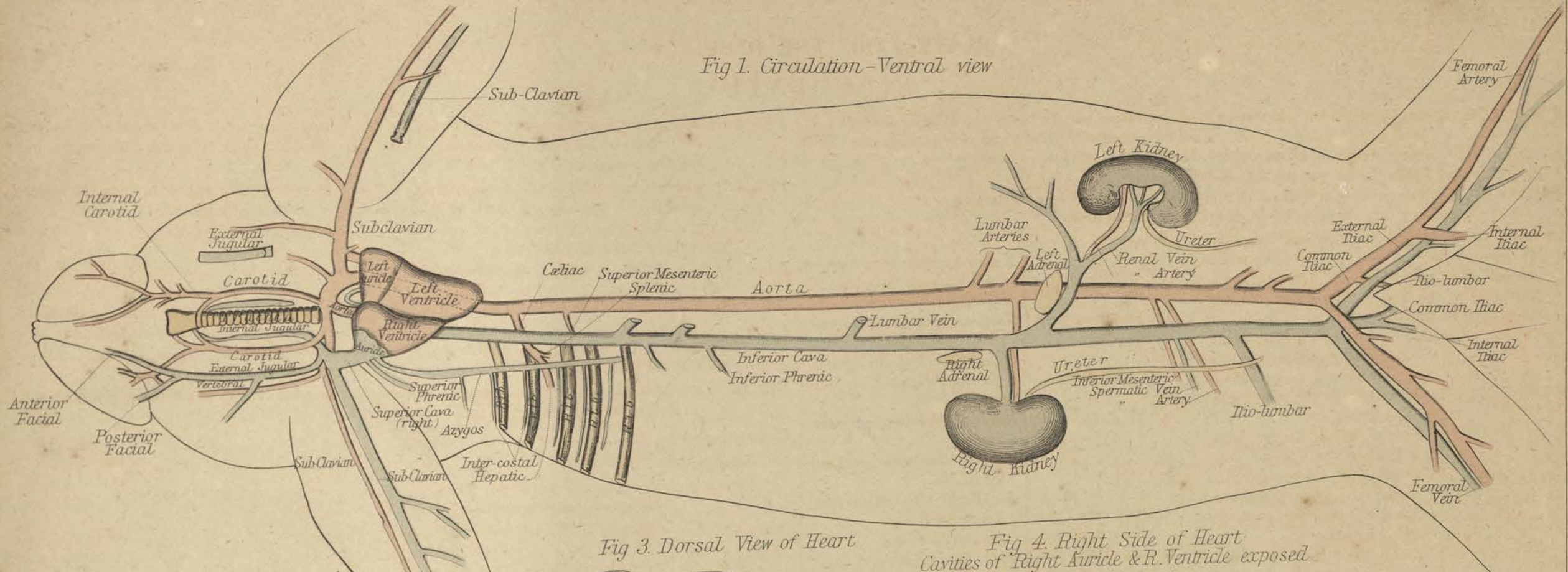

Fig 2. Heart turned over to right side

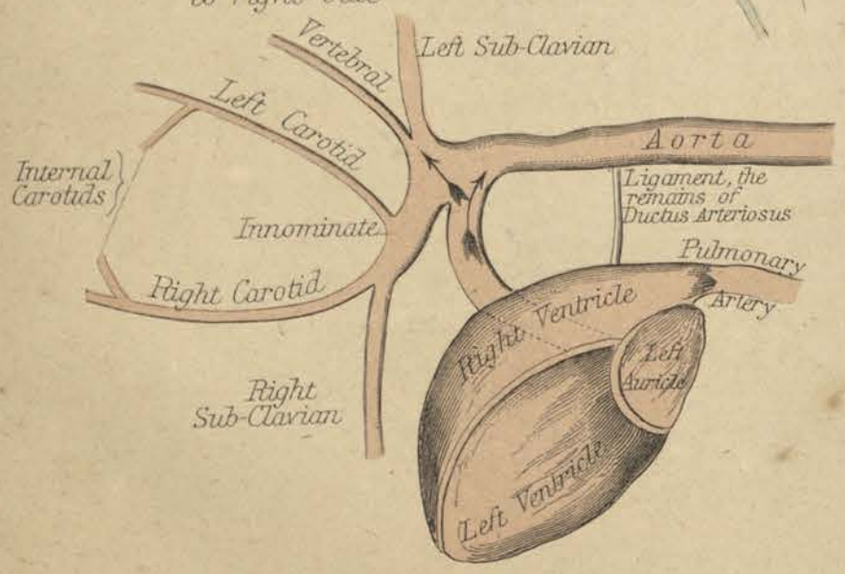

Fig 3. Dorsal View of Heart

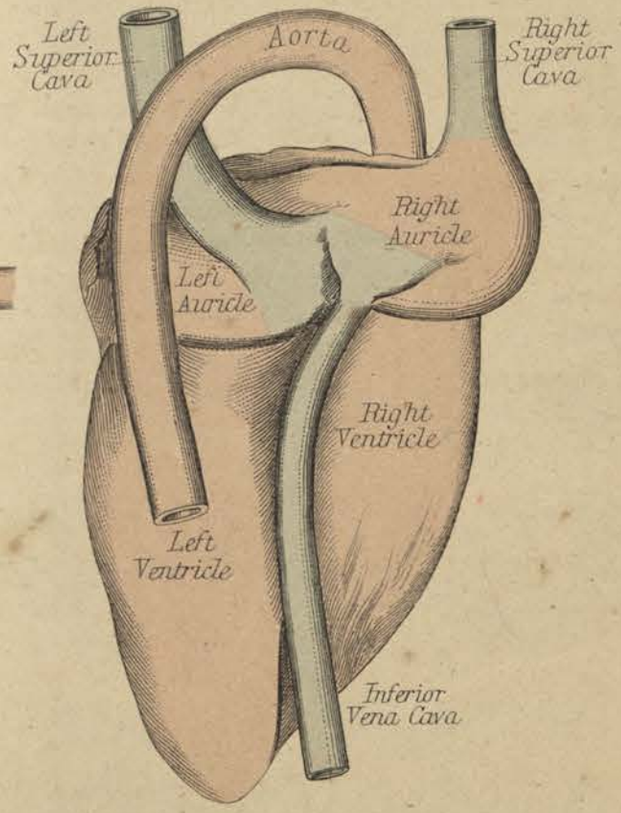

Fig 4. Right Side of Heart
Cavities of Right Auricle & R. Ventricle exposed

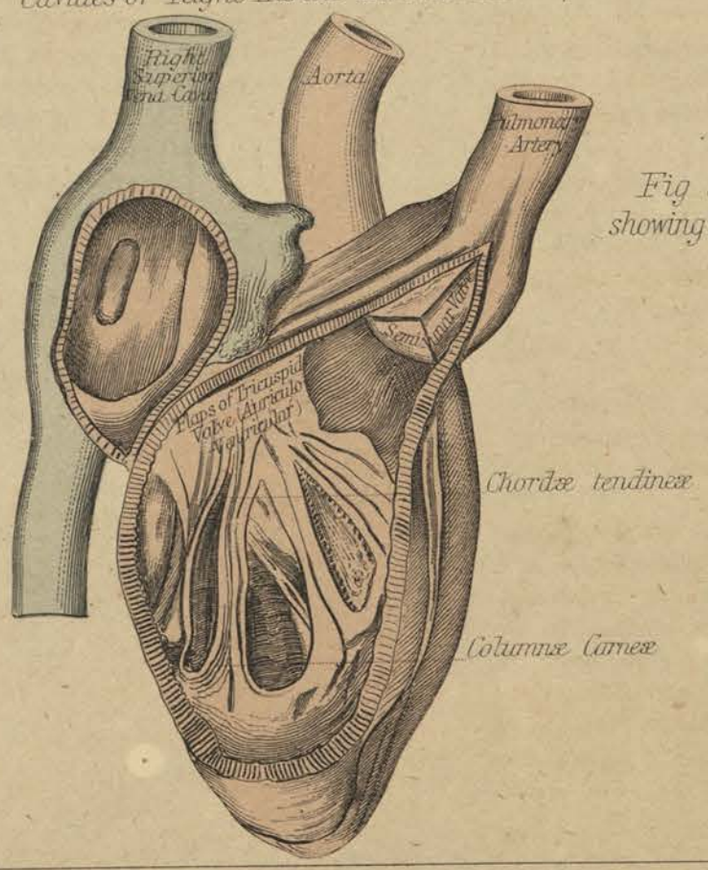

Fig 5. Vein laid open showing 2 pouches of Valve

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PLATE XXIV.—THE RABBIT—*concluded*.

URINO-GENITAL ORGANS.

FIG. 1. Kidneys, the left lower than right, surfaces smooth.

Ureters opening into urinary bladder.

Descent of the Testes.—The testes are originally developed close to the kidneys, but by-and-by they begin to move backwards, carrying with them their investing peritoneum. Finally they project in the pubic region, and the pouch of skin thus formed is the scrotal sac. A number of the fibres of the internal oblique muscle of the abdomen is carried down at the same time, constituting the cremaster muscle.

Testis inside scrotal sac (L. *scrotum*, a hide); right testis shown retracted into abdomen.

Epididymis, consisting of caput (L. the head) and cauda (L. the tail).

Vas deferens opening into uterus masculinus.

Gubernaculum (L. a pilot) connecting cauda epididymis with scrotal sac.

Scrotal sac consisting of the following coats:—
- Outer skin.
- Dartos (Gr. *deras*, a skin), connective tissue.
- Cremaster muscle (Gr. *kremas*, I suspend), by the contraction of which the seminal fluid is driven out of the testes.
- Tunica vaginalis (L. ensheathing tunic), peritoneum lining the sac.

Uterus masculinus (L. male womb), a sac posterior to bladder.

Prostate gland consisting of five lobes.

Cowper's glands, two oval bodies.

Rectal glands, one on each side of rectum.

Perineal glands, one on each side of free end of penis, the secretions of which give the Rabbit its characteristic smell.

Urethra, a tube continuous with urinary bladder opening at free end of penis.

Penis composed of spongy erectile tissue . . . .
- Corpora cavernosa, connected anteriorly with ischia, and passing posteriorly in close contact to the root of glans.
- Corpus spongiosum (L. spongy body), surrounding urethra and continuous posteriorly with
- Glans, the free terminal portion.
- Prepuce (L. *præputium*, the foreskin), the loose integument.

Kidney in section . . . .
- Hilus, the inner concave portion.
- Pelvis (L. a basin), the cavity in which ureter originates.
- Urinary pyramid, the projection into pelvis.
- Medullary portion striated.
- Cortical portion dotted.

FIG. 2.

Openings in order from before backwards . . . . .
- Ureters into bladder.
- Uterus masculinus into urethra.
- Prostatic ducts into urethra.
- Cowper's glands into urethra.

Verumon'tanum is a round projection in the prostatic region of urethra.

FIGS. 3 and 4. Ovary, a small oval body close to opening of Fallopian tube on each side, with numerous prominences, the Graafian follicles (fig. 5).

Fallopian tube, narrow, and passing into wide uterus.

Vagina (L. a sheath), with which each uterus communicates by the os uteri (L. mouth of the uterus).

Vestibule (L. *vestibulum*, an entrance), corresponding to urethra, opening externally and communicating internally with bladder and vagina.

Cowper's glands, Rectal glands, Perineal glands } Fig. 4.

Clitoris, a white rod formed by the two corpora cavernosa, and ending in the glans clitoris.

FIG. 5. Stroma, the fundamental tissue in which the other parts are embedded.

Graafian follicles, the capsules in which the ova are developed.

Mature ovarian ovum is about $\frac{1}{150}$th inch in diameter.

Fig. 1 Urinogenital Organs—Male
(dorsal view)

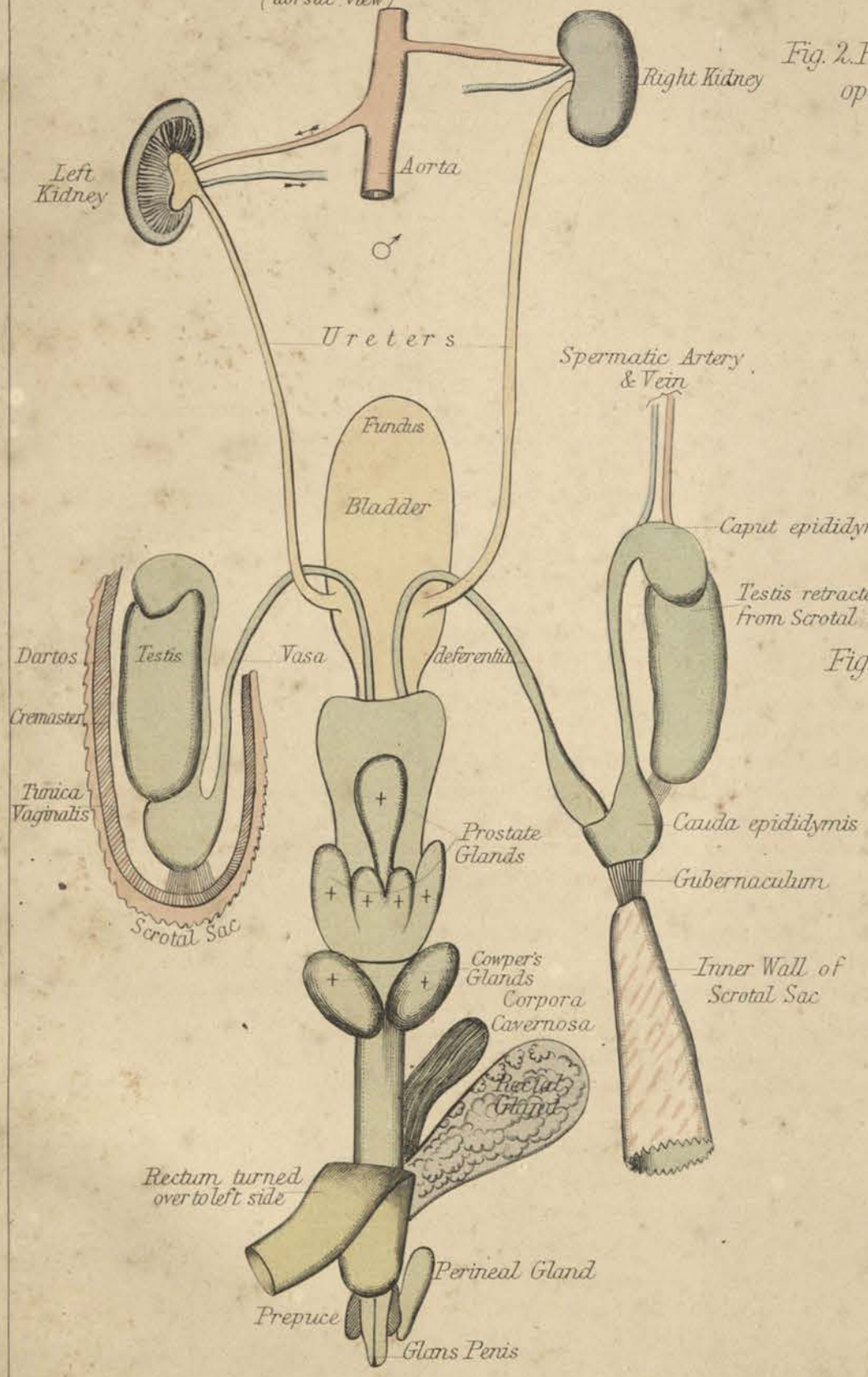


Fig. 2. Portion of Male Urinogenital Organs laid open from ventral surface showing openings

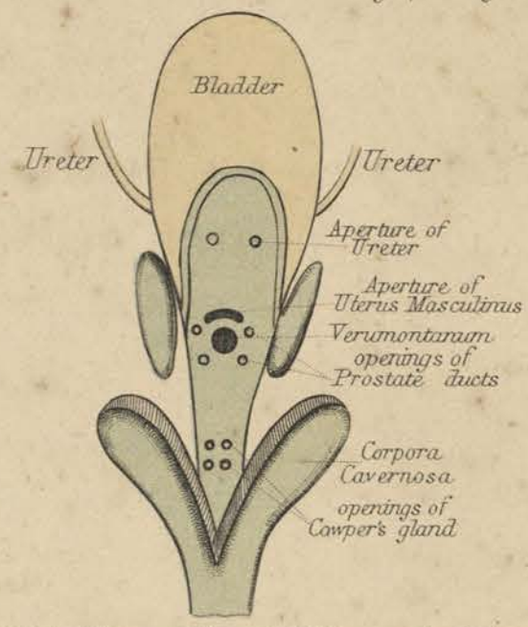


Fig. 3. Urinogenital Organs-Female
(ventral view)

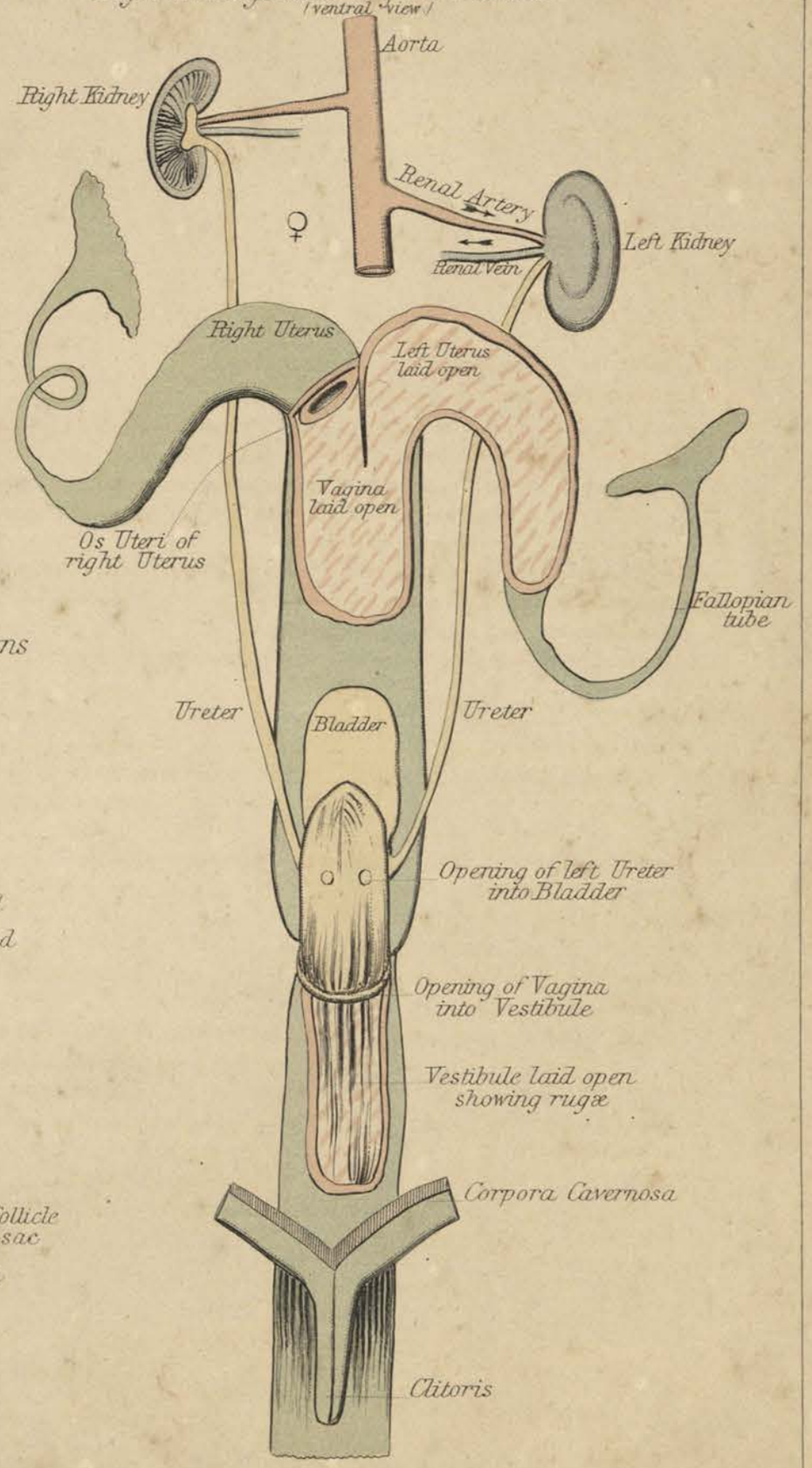


Fig. 4. Side View of Female Urinogenital Organs

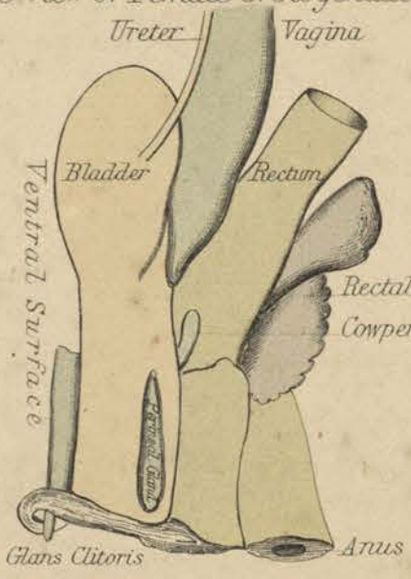
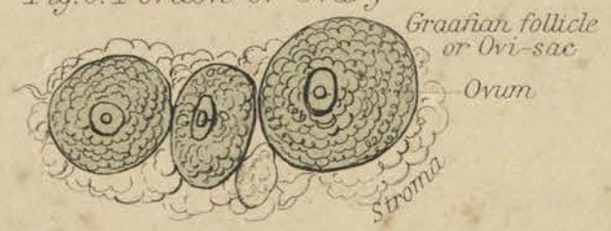


Fig. 5. Portion of Ovary



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